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THE COLORS OF NORTHERN GAMOPETALOUS FLOWERS (*continued*).

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THE Lentibulariaceæ, or bladderwort family, are mostly aquatic or marsh plants. Only four genera and one hundred and eighty species are known. The flowers are yellow, or vary from yellow to purple and violet-blue. Of the fourteen species of Utricularia, or bladderwort, eleven species are yellow and three purple. The rootless plants of *Utricularia vulgaris* float near the surface during inflorescence. The deeply 2-lipped flowers are bright yellow with the palate marked with reddish-brown lines leading well down into the spur, which secretes the nectar. According to Knuth, Heinsius found the flowers visited only by long-tongued Syrphidæ, the species *Helophilus lineatus* being most numerous. This is certainly surprising as the closed flowers appear adapted to bees. As the species is aquatic considerable patience is required to observe the visitors. After repeated observations I have collected on the flowers in Maine only the syrphid fly *Helophilus conostomus*. Like Utricularia the genus Pinguicula is carnivorous, and the yellowish-green leaves are thickly covered with sticky glands. The flowers are violet-

blue with the palate covered with velvety white hairs. The visitors are flies and bees.

The Orobanchacæ are parasitic plants without chlorophyll, usually colored yellowish or purplish. The flowers also are frequently yellowish or purple. In variety luteum of *Aphyllon fasciculatum* the whole plant is yellow. Sometimes the flowers are bicolored, yellow or white, and purple.

The Bignoniaceae, or trumpet-creeper family, occur chiefly in the tropics. Many of the species are bird flowers, one to two inches in length, and crimson, orange or scarlet, as *Bignonia venusta* and *Tecoma radicans*. Common examples of bird flowers in North America are *Lobelia cardinalis*, *Gossypium herbaceum* and *Lonicera sempervirens*. The ruby-throated humming-bird, however, visits many flowers fertilized by insects. The Acanthaceæ, a large tropical family of some 1800 species, also contains many scarlet bird flowers.

The order Plantaginales includes but a single family, the Plantaginaceæ, or plantain family. The inflorescence is in spikes with small 4-merous flowers, which are mostly greenish or purplish, and are wind-fertilized. They are of special interest because they show the beginnings of adaptations to insect visitors. In one or more species, "we have before us the passage from anemophilous to entomophilous characters, the evolution of an entomophilous from an anemophilous species." *Plantago media* possesses a pleasant perfume and reddish filaments. Müller distinguishes an anemophilous and an entomophilous form, which differ slightly in color, the stamens, stigmas, and pollen. Twenty-four visitors have been collected on the flowers. The limb of the corolla and sometimes the border of the sepals of *P. alpina* is red. Five insects in the Alps have been collected on this species. According to Knuth, the flowers of Plantago display a variety of colors; in *P. major* the corolla is brownish, the filaments white, the anthers red, brown, or sometimes yellow or even white, while in other species yellow, red and violet appear.

The three orders, Rubiales, Valerianales, and Campanulales, which terminate the Gamopetalæ, exhibit many affinities with the families, which stand at the close of the Choripetalous

series. The individual flowers are usually small, and conspicuousness is gained by aggregation. The inflorescence is cymose forming in the Dipsaceæ and Compositæ dense involucrate heads, and not infrequently contracted in the other families belonging to this group into capitate clusters provided with an involucre, as in *Cephaëlis ipecacuana* of the Rubiaceæ. Both actinomorphic and zygomorphic flowers occur, and the sexes may be united or separated. By some writers the Rubiaceæ are derived from the Umbelliferæ. While this derivation is doubtful the terminal groups of the Choripetalæ and Gamopetalæ certainly possess many points of resemblance, which indicate a parallel development.

The Rubiales, which include the Rubiaceæ and Caprifoliaceæ, have opposite leaves, and usually the stipules are present in the first of the two families but rarely in the second. Stipules occur elsewhere in the Gamopetalæ only in the primitive stem family of the Loganiaceæ. The corolla varies greatly in length from rotate to funnelform and tubular, and is in consequence adapted to a great variety of visitors.

The Rubiaceæ, or madder family, is of immense extent in the tropics and contains about 5500 species. No other family contains so many dimorphous flowers. The roots of several species, as *Rubia tinctorum* and *Galium boreale* contain a red pigment (madder red), which is widely used in dyeing. The flowers of Galium, or bedstraw, are very small or minute, with the calyx obsolete. In *G. triflorum* and *G. circæzans* the flowers are green, in *G. boreale* and *G. mollugo* white, in *G. verum* yellow, in *G. rubrum* red, and in *G. purpureum* purple. The visitors are chiefly flies, and the great variety of colors affords evidence that they do not prefer one hue to another. Indeed the coloration of the different species is probably determined by internal conditions. *Houstonia cœrulea*, or bluets, one of the common spring flowers, is pale blue or nearly white with a yellow eye. So abundant is this little plant that it often tinges the hillsides and meadows. Other species are blue or purple.

The Caprifoliaceæ, or honeysuckle family, are remarkable for the variation in length of the corolla tube, and the consequent adaptation of the flowers to a great variety of visitors. The

white, wheel-shaped flowers of Sambucus contain no honey, and are sparingly visited by flies and pollen-collecting bees. The large, pyramidal or flat cymes are very numerous and conspicuous. The small, rotate flowers of Viburnum are in large compound cymes, which bloom in early spring and midsummer. They are white, fragrant, and nectariferous. The most important visitors are Andrenidæ, flies and beetles, to which the inflorescence with its freely exposed honey is well adapted. I have found beetles more abundant and in greater variety than upon any other northern plants. The marginal flowers of *V. alnifolium* and *V. opulus* are sterile and greatly enlarged.

There are a few flowers adapted to wasps and to which these insects are very frequent visitors. The most important wasp flowers are *Epipactis latifolia*, *Cotoneaster vulgaris*, *Scrophularia nodosa*, *Symphoricarpos racemosa*, and *Lonicera alpigena*, the last two belonging to the Caprifoliaceæ. The flowers agree in having abundant honey secreted in a short corolla, or pouch-like receptacle, about the size of a wasp's head, and usually lurid colors. In England Darwin found *Epipactis latifolia* visited by swarms of wasps, but was astonished to observe that the sweet nectar never proved attractive to any kind of bee or dipterous insect. The small reddish flowers of *Symphoricarpos racemosus* (snow berry) are campanulate and pendulous. Wasps thrust their heads wholly into the flower to obtain the nectar. *Lonicera alpigena* is reddish-brown. Müller observed in the Alps that it was visited by two species of wasps in great numbers.

The nodding blossoms of *Linnæa borealis* are wine colored with a yellow marking on the lower side, which serves as a honey-guide, and exhale a sweet vanilla-like fragrance. It is a trailing evergreen vine densely carpeting the ground in cold, open woodlands. I have collected on the flowers only the fly *Empis rufescens*, which is rather common.

The large genus Lonicera is adapted to a variety of visitors. The wasp flower *L. alpigena* is reddish-brown. The bee flower *L. tartarica* is pink or white. The bumblebee flowers, *L. ciliata*, *L. xylosteum* and *L. cærulea* are yellow. The hawkmoth flower *L. periclymenum* on the first evening it expands is white within, changing to yellow on the second evening. The exterior of the

flowers is purplish-red, and in fading they turn to a dingy orange-brown. The bird flower *L. sempervirens* is scentless, scarlet outside and yellow within, or rarely throughout. The corolla of *Diervilla trifida*, or bush honeysuckle, is light yellow with an orange honey guide on the upper lobe. The older flowers turn reddish, a color change which also occurs in *Ribes aureum* and in the genera Weigelia, Fuchsia, and Lantana. In *Ribes aureum* Müller states that the more intelligent insects immediately recognize by means of their red color those flowers which no longer contain nectar, and consequently visit more blossoms in the same time. Repeated observations by the writer failed to show that the color change in Diervilla was of the same significance. The honeybee was observed to visit the red flowers both when solitary and when associated with yellow flowers. Neither was there any preference manifested for yellow flowers, when flowers of both colors occurred in the same cyme. An immense number of varieties of Weigelia have been produced in cultivation by selection and hybridization, which are remarkable for their wide range of coloring. There are white and deep red forms with every intermediate shade ; white when opening but changing to rose ; deep red in bud but rose-colored in bloom ; flowers pale rose at first, changing to deep red ; yellow ; light yellow, changing to white ; pale yellow, changing to pale rose ; and reddish-purple.

The herbaceous order Valerianales is intermediate between the Rubiales and the Campanulales. The flowers of the Valerianaceæ are in clustered cymes and are usually white or reddish. The inflorescence of the Dipsaceæ, or teasel family, is in involucrate, purplish heads, and is attractive to a great number and variety of insects. *Scabiosa atropurpurea* of the garden is black-purple, scarlet, or white. The distinct anthers and hanging ovule separate this family from the following order.

The Cucurbitaceæ, or gourd family, were formerly classed with the Choripetalæ, but are now placed in the order Campanulales with the Campanulaceæ and Compositæ. The species are herbaceous, tendril-bearing vines found chiefly in the tropics. The petals are separate or united. The smaller flowers of this family are white or greenish and the larger are yellow. The

pollinators are bees. "The flowers of a species of Trianosperma in South Brazil are visited, according to Fritz Müller, very abundantly all day long by *Apis mellifica* and a species of Melipona, although they are scentless, greenish, quite inconspicuous and to a great extent hidden by the leaves." In this instance as in some others the bees are probably guided by past experience in looking for the nectar. The large flowers of the cultivated Cucurbita are often wholly or partially concealed by the leaves, yet are readily found by bees.

The stem-family, or line from which the other families of this order are derived, is the Campanulaceæ, or bell-flower family. Of the twenty-three northern species one is red and twenty-two are blue. The flowers of Campanula are campanulate or rotate, blue or white, and are visited by many Hymenoptera. Lobelia has zygomorphic flowers which are usually blue or white. But *L. cardinalis*, *fugens*, *splendens* and *texenis*, have fiery red corollas adapted to humming-birds. There is no more brilliant red color in the northern flora than that of the corolla of *L. cardinalis*. Phyteuma and Jasione are transition genera.

At the head of the gamopetalous series stand the great family of the Compositæ, which includes such familiar and widely distributed plants as the thistle, aster, goldenrod, daisy and dandelion. About 1000 genera and 12,000 species have been described. Multitudes of these hardy weeds grow luxuriantly in our fields, and along our highways and hedgerows; and exhibit a remarkable vigor and ability to thrive under the most untoward conditions. Many of the species tend to become cosmopolitan, and have spread over both continents. The inflorescence represents Nature's greatest triumph in flower building. Intercrossing by insects, economy of time and material, a large number of seeds well adapted to germinate, and their wide distribution, have all been very perfectly attained. The individual flower is often very small, and of little significance as compared with the community. Conspicuousness is gained by massing a large number of flowers in a head, an arrangement that also permits insects to visit them very rapidly. In the goldenrod a head consists of ten or fifteen florets, while in the white weed the number may exceed five hundred. The capitulum with

its enfolding bracts often resembles a single flower, and was termed by the older botanists a compound flower. The life history of the individual florets may be conveniently studied in the garden sunflower, where they are of comparatively large size.

The Cichoriaceæ, or chicory family, are often treated as a tribe of the Compositæ. There are 8 white, 53 yellow, 5 red, 2 purple and 5 blue species. All of the flowers of the head are strap-shaped or ligulate, as in the dandelion. This species *Taraxacum taraxacum* (*T. officinale*) is gregarious, and in some localities the plants are so numerous that the inflorescence covers with a bright sheet of golden yellow entire hillsides. The visitors are numerous; in Low Germany Müller collected 67 Apidæ, 7 Lepidoptera, 25 Diptera and 16 other insects. Most of the genera of this family have yellow flowers as Hieracium (hawkweed), Latuca (lettuce) and Sonchus (sow thistle), but as a rule they are much less conspicuous than the dandelion and have fewer visitors. The great number of yellow flowers in this family have already been referred to under the Scrophulariaceæ. *Cichorium intybus* (chicory) has large bright blue flowers with white and pink variations.

The Ambrosiaceæ, or ragweed family, are composed of small greenish flowers, which in the absence of insects have reverted to wind-fertilization. In Ambrosia the corolla has been lost. At an earlier stage the flowers were homogamous or self-fertilized, as is still the case in *Senecio vulgaris* which is visited rarely by insects. The flowers excellently illustrate the fact that inconspicuousness is due to the absence of insects.

In the Compositæ the flowers are either tubular and all alike, when the head is called discoid; or the disk flowers are tubular and the marginal flowers are ligulate, when the head is radiate. There are 21 green, 126 white, 209 yellow, 4 red, 64 purple, and 59 blue flowers.[1] When the heads are discoid the flowers are all of the same color, but when they are radiate they are frequently bicolored. In the garden daisy, or *Bellis perennis*, the disk flowers are yellow, and the ray flowers are white, pink, or purple, with purple bracts. In Townsendia the disk flowers

[1] In classifying bicolored capitula preference is given to the color of the rays.

are yellow, and the ray flowers are white, violet, or purple. In Aster the rays are white, pink, purple, or blue, and the disk flowers are yellow turning to red-purple or brown. In the China asters (Callistephus) there is a great variety of colors, and a single head is often tricolored, as a yellow center surrounded by an inner white ring and an outer ring of purple. The ray flowers of this genus may display almost every imaginable shade of color, and individual flowers may change from white to rosy red or lilac. But in Helianthus and in part of the species of Coreopsis both ray and disk flowers are golden yellow. The original color of the genera, which was usually yellow, is preserved by the central or disk flowers. The rays may vary from yellow to white, red, purple or blue, and an innumerable number of intermediate shades. Under cultivation *Chrysanthemum sinense* has yielded a multitude of magnificent flowers. The ray flowers have increased in number until they compose the entire head, and there is scarce a tint or shade save blue that is not known. The original colors were a pale yellow, a white and a very weak violet shade, and from these have been raised all the colors and shades now seen in this flower. "This has been accomplished by a very slow and persistent selection and cross-fertilization. It is worthy of notice how intensified the yellows have become, and how many shades of this color there now are. The lilac has become pink of pure shading; then, as to red, *cullingfordii* often presents us with a pure tone of red. The most pronounced purple we have to-day is from the lightly tipped, incurved Princess of Wales, being a sport named Violet Tomlin. It is really purple. Now we cannot get purple without blue, and to those who are at work in this field of development, a blue chrysanthemum would not be such a great surprise." [1]

Throughout the Compositæ the corolla has remained of small size, and there is no reason to suppose it has ever been greatly modified in form. The primitive colors have also been very largely retained, for out of 483 northern species 209 are yellow and 126 white. Fifty of our genera contain yellow flowers, and some large genera consist wholly of flowers of this color,

[1] Thorpe, J. *Amer. Garden*, vol. xi, No. 1, p. 4.

as Chrysopsis, or golden aster, Solidago (with one exception), and Senecio. The capitula are both discoid and radiate, and as a rule both ray and disk flowers are yellow. But the disk flowers in some genera have become brown or purple. In Rudbeckia, or cone flower, the rays are yellow and the disk purple; in Helianthus six species have the disk purple or brown, and in sixteen species the disk is yellow; and in Coreopsis both rays and disk vary from yellow to brown.

One hundred and twenty-six species have white flowers. In many instances where the ray flowers are white the disk flowers are yellow. In these bicolored capitula there can be little doubt that the white rays are derived from yellow-flowered progenitors. In Verbesina (crownsbeard) all of the five species have yellow disks, but one has white and four yellow rays. The white discoid heads seem also to have been originally yellow. Of the discoid heads of Hymenoppapus two species are yellow and three are white. A number of genera, as Antennaria, Filago and Gnaphalium, consist of white woolly herbs with yellowish white often inconspicuous flowers, which have undergone much retrogression. The white-flowered species appear to be of later origin than the yellow, and in numerous instances to be derived from them.

There are only four red to sixty-four purple, and fifty-nine blue flowers. The heads are both discoid and radiate. While the rays may change directly from yellow to red, purple, or blue, in many instances they have probably passed through an intermediate white stage. In Boltonia, which has the disk yellow, one species has the rays white, and in two others they are blue or violet. In Aster the rays are white in twenty-two species, purple in six, and blue in forty-four. In Erigeron the white rayed species frequently vary to pink or purple. In Coreopsis twelve species have the rays yellow like the disk, but in one they are pink, and in the variety Golden Wave they often change from golden yellow to maroon. In some species of Aster the disk flowers change from yellow to red or blue, as in *A. roscidus*, *A. carmesinus*, and in *A. curvescens*. Whether the purple discoid flowers of Vernonia (iron-weed) have passed through a yellow stage there is little evidence. The flowers of Artemisia (worm-

wood) have reverted to wind-fertilization and are greenish or yellowish.

The individual flower in the Compositæ is small and of little significance. Conspicuousness is gained by massing first the flowers, then the capitula, and finally the plants themselves. If the capitulum is large, as in Helianthus, it may be solitary, but if small, as in Solidago, they may be aggregated into dense flower-clusters. Many species are, moreover, gregarious, and so abundant that they constitute important features in the floral landscape. Such are the white weed, thistle, sunflower, goldenrod, and aster. Kerner states that in New Zealand the small white flowers of Haastia are so densely aggregated that they form hemispherical mounds two feet high by three feet in length. The plant is known as "vegetable sheep" since at a distance it is frequently mistaken for that animal.

With the exception of the Umbelliferæ, or carrot family, no flowers are visited by so large and miscellaneous a company of insects as the Compositæ. The guests of a single species may exceed one hundred in number. The nectar is more deeply concealed than in the Umbelliferæ, and the percentage of long-tongued visitors is consequently much greater. Throughout the Compositæ bright coloration is correlated with pollination by insects; and when a genus reverts to wind-fertilization, the inflorescence becomes inconspicuous. It is interesting to note that the species, which attract the largest number of visitors, display a variety of colors, as in the bright yellow goldenrods, *Chrysanthemum leucanthemum* with white rays and a yellow disk, *Achillea millefolium* white or tinged with red, the asters with a yellow disk and white or blue rays, and the purple-flowered Canada thistle. These differently colored species are visited by a large company of Hymenoptera, Lepidoptera, Diptera and Coleoptera, which are influenced by the length of the corolla tube and the degree of conspicuousness obtained by a contrast of colors and by massing; but there does not seem to be any evidence that they find greater pleasure in one hue than in another. The white-flowered *Eupatorium perfoliatum* (thoroughwort) in this locality is visited by a larger number of butterflies than any other Composite plant. Bumblebees are also very common and

as pollinators far more important than the butterflies. No one, however, would claim that the color of this species was due to the selective influence of either bees or butterflies. In a woodland pasture I found two large patches of the common elecampane, or *Inula helenium*, and the Canada thistle growing side by side. The yellowish-red butterfly, *Argynnis aphrodite* was flitting about upon the large yellow flowers of Inula, for which it showed a decided preference, though occasionally it was observed to fly over to the purple flowers of the thistle. The white cabbage butterfly on the contrary confined its visits almost exclusively to the thistle blooms. As red has been supposed to be the favorite color of butterflies, this singular behavior must have been determined by other causes than the colors of the flowers. *Argynnis aphrodite* also very frequently visits the small white flowers of *Aralia hispida*, and *Pieris rapæ* delights in the white or reddish flowers of the garden radish.

Bees not infrequently pass from one species to another in this family, both when the flowers are closely allied and when they are widely different. I have often seen bumblebees pass from one species of goldenrod to another, and even back and forth between goldenrods and asters. Occasionally I have seen them pass between very different forms of flowers, as between sunflowers and the scarlet runner, or the goldenrod and the purple vervain (*Verbena hastata*). On the other hand the honeybee often displays a remarkable power of distinguishing between closely allied species, even when they are of the same color. One of the common golden-rods *Solidago lanceolata* has its capitula arranged in a crowded, flat-topped corymb. Another common variety *S. rugosa* has the inflorescence panicled. In an upland pasture these two species were found growing together, the panicled form being much the more abundant. Honeybees, the only insects present, showed a marked preference for *S. lanceolata*, though they occasionally passed over to the other species. They were repeatedly seen to leave *S. lanceolata*, and after flying about but not resting on the flowers of *S. rugosa* return to the plants they had left only a few moments before. In another instance a bee was seen to wind its way among the plants of the latter species until it found an isolated plant of *S. lanceolata*.

A plant of each of the above species was bent over so that the blossoms were intermingled, appearing as a single cluster ; a honeybee rested on *S. lanceolata*, and it seemed very probable that it would pass over to the flowers of *S. rugosa*, but such was not the case, for presently it flew away to another plant of the former. The behavior of these bees in their endeavors to adhere to a single species was thus attended both by loss of time and repeated visits to the same blossoms. On another occasion the whitish or cream-colored inflorescence of *Solidago bicolor* was observed to be very frequently visited by the males of *Bombus bifarius*, while the yellow-flowered goldenrods in the vicinity were entirely neglected. By holding yellow-flowered clusters directly in their way, I repeatedly induced these bees to leave *S. bicolor*; but they quickly perceived that they had passed to a different flower, and invariably after a few seconds or sometimes instantly returned to the cream-colored species. They were probably influenced by the greater supply of nectar in the flowers of *S. bicolor*. The plants, which were growing on burnt land, were of unusually large size, and secreted nectar very freely as I ascertained by examination on my return home. These illustrations are sufficient to show that the influence of particular colors in determining the visits of insects may be easily overestimated.

THE COLORS OF NORTHERN GAMOPETALOUS FLOWERS.

Orders.	Families.	Green.	White.	Yellow.	Red.	Purple.	Blue.	Total.
Ericales	Clethraceæ		2					2
	Pyrolaceæ	1	7		2	1		11
	Monotropaceæ		3		1			4
	Ericaceæ		22	1	10	5		38
	Vacciniaceæ	2	10		11			23
	Diapensiaceæ		3					3
Primulales	Primulaceæ		4	11	7			22
	Plumbaginaceæ				1	1		2
Ebenales	Sapotaceæ		2					2
	Ebenaceæ			1				1
	Symplocaceæ			1				1
	Styraceæ		4					4
Gentianales	Oleaceæ	7	2			1		10
	Loganiaceæ		2	1	1			4
	Gentianaceæ		7	1	10	4	16	38
	Menyanthaceæ		2	2				4
	Apocynaceæ		2	1	1	1	2	7
	Asclepiadaceæ	7	11	3	5	13		39
Polemoniales	Convolvulaceæ		7	1	7		3	18
	Cuscutaceæ		11		1			12
	Polemoniaceæ		7		10	3	8	28
	Hydrophyllaceæ		8				10	18
	Boraginaceæ		19	6		1	17	43
	Verbenaceæ		2			2	8	12
	Labiatæ		24	4	12	47	33	120
	Solanaceæ		9	21		2	8	40
	Scrophulariaceæ		13	33	7	32	28	113
	Lentibulariaceæ			11		3	2	16
	Orobanchaceæ		1	2		2	2	7
	Bignoniaceæ		2	1	1			4
	Martyniaceæ		1					1
	Acanthaceæ				1	1	5	7
	Phrymaceæ					1		1
Plantaginales	Plantaginaceæ	14	1					15
Rubiales	Rubiaceæ	4	22	1		7	5	39
	Caprifoliaceæ		22	11	4	1		38
	Adoxaceæ	1						1
Valerianales	Valerianaceæ		5		4		1	10
	Dipsaceæ					4		4
Campanulales	Cucurbitaceæ		4	1				5
	Campanulaceæ				1		22	23
	Cichoriaceæ		8	53	5	2	5	73
	Ambrosiaceæ	15						15
	Compositæ	21	126	209	4	64	59	483
	Total	72	375	376	106	198	234	1361

SUMMARY AND CONCLUSIONS.

Numerical Summary.—In the territory extending northward from the parallel of the northern boundary of North Carolina and Tennessee to the northern limits of Labrador and Manitoba, and from the Atlantic Ocean westward to the 102d meridian, there are recognized in the Illustrated Flora of Britton and Brown 4020 angiospermous plants. In the following table the species belonging to the different series have been arranged according to their predominant floral colors.

Series.	Green.	White.	Yellow.	Red.	Purple.	Blue.	Total.
Monocotyledons	857	82	41	22	22	34	1058
Dicotyledons							
Choripetalæ							
Apetalæ . .	175	89	51	45	24		384
Polypetalæ .	140	410	333	84	193	57	1217
Gamopetalæ .	72	375	376	106	198	234	1361
Total . .	1244	956	801	257	437	325	4020

In every 100 species there are 30.9 green, 23.8 white, 19.9 yellow, 06.4 red, 10.9 purple and 08. blue. The hydrophilous and anemophilous species within this area, I place at about 1048, of which 1021 are green, 1 white, 11 yellow, 3 red and 12 purple. A number of species vary between wind-fertilization and insect-fertilization, and are differently classed by different observers. *Empetrum nigrum* according to Warming is a wind-flower, according to Lindman an insect flower, and according to Knuth it is a wind-flower with occasional insect visits. There are then in the district under consideration 2972 species, which are fertilized by insects or are self-fertilized. Of this number 223 are green, 955 white, 790 yellow, 254 red, 425 purple, and 325 blue. In every 100 of these plants 07.5 are green, 32.1 white, 26.6 yellow, 08.5 red, 14.3 purple, and 10.9 blue. It is evident that anemophily and small greenish flowers are correlated, and that large bright colored flowers are due to insect fertilization. The 1048 Anemophilæ and Hydrophilæ are dis-

tributed as follows: — Monocotyledones 802 green; Apetalæ 134 green, 1 white, 11 yellow, 2 red, and 4 purple; Polypetalæ 27 green, 1 red, and 8 purple; Gamopetalæ 58 green species.

The Pigments. — The colors of angiospermous plants are due to three groups of pigments, occurring either singly or associated together; the green pigments or chlorophyll; the yellow pigments which include carotin, xanthophyll and phyllofuscin; and the soluble red and blue pigments or anthocyan.

Chlorophyll. — The characteristic green shades of foliage are caused by chlorophyll, the most common of all plant pigments. With the exception of the Fungi it is found in nearly all forms of vegetation, though its presence is often partially masqued, as in the Algae, by its association with other coloring substances. Its wide distribution is explained by its activity in the synthesis of carbohydrates. According to several late investigators there is more than one kind of chlorophyll. This view was adopted in 1895 by Gautier and Etard. Kohl in his recent work on "Carotin" admits of two varieties, which he designates as α-chlorophyll and β-chlorophyll.[1] In a green leaf "the normal chloroplasts contain much α-chlorophyll, little β-chlorophyll, much carotin, little α-xanthophyll, and little β-xanthophyll."[2] The α-chlorophyll is to be regarded as pure chlorophyll. Its absorption bands lie in the red half of the spectrum. The genetic relations of chlorophyll require further investigation. Wiesner's theory that etiolin is the mother substance of chlorophyll has not been proven; and, according to Kohl, it can be shown that in the greening of etiolated plants chlorophyll is not formed at the expense of the etiolin. The different shades of green observable in foliage are due partly to the quantity and arrangement of the chloroplasts. The upper side of a leaf is usually a darker green than the lower, because the palisade cells contain three or four times as many chlorophyll granules as the spongy parenchyma of the lower side.[3] Ferns and mosses, which habitually live in shady ravines, are a deeper green in

[1] Kohl, F. G. *Untersuchungen über das Carotin und seine physiologische Bedeutung in der Pflanze*, p. 139.

[2] Ibid. p. 145.

[3] Kerner. *Natural History of Plants*, vol. i, p. 374.

such locations than when they grow in the open sunlight. The color is also affected by a change in the position of the granules under the action of intense light, as may be observed in *Lemna trisulca* and many seaweeds.[1] Chlorophyll is readily soluble in alcohol yielding a green solution, which is soon destroyed in direct sunlight. There is a constant destruction and renewal of chlorophyll in living leaves under the action of bright light, so that on the same plant the leaves present different shades of green. Green seaweeds, when left on the beach by the waves, soon turn yellowish owing to the destruction of the chlorophyll.

Leaves and flowers may in some instances owe their particular shade of color to the presence of chlorophyll mixed with some other pigment. The dull purple of *Scopolia atroipoides* and *Atropa belladonna*, according to Hildebrand, are caused by green grains mingled with violet-colored sap. In the gooseberry, says Möbius, the brownish color of the flower is due to an upper layer of cells containing red cell sap, and an under layer containing chlorophyll. Many greenish yellow and purple flowers appear to contain chlorophyll. The tints of autumn leaves are also modified by its presence in greater or less quantities, while in normal green leaves it is often accompanied by anthocyan.

Yellow Pigments.—Chlorophyll is invariably accompanied in the chloroplasts by carotin, the yellow pigment so common in the root of the carrot. Tammes[2] and Kohl[3] found carotin to be widely distributed in the blue, green, red, and brown Algæ; in the Fungi, lichens, mosses, and ferns; in green, yellow, etiolated and autumn leaves; and in flowers, fruits and seeds. There is, however, no evidence of any genetic relation between the two pigments; and carotin may exist independently in organisms in which chlorophyll does not occur, as in Bacteria, fungi, the root of *Daucus carota* and in yellow flowers and leaves. Kohl finds that etiolin is identical with carotin, and adds that the term etiolin in the sense used by Pringsheim

[1] Sach. *Physiology of Plants*, p. 618.

[2] Tammes, Tine. Ueber die Verbreitung des Carotins in Pflanzenreiche. *Flora od. Allg. bot. Zeitung.* Bd. 87, H. 2, p. 244.

[3] The distribution and properties of the yellow pigments are discussed at length in Kohl's exhaustive work on Carotin.

should be stricken from the list of plant pigments. Etiolated plant organs owe their coloring exclusively to carotin, with which is often associated anthocyan. Also identical with carotin are xanthopyll and anthoxanthin as these terms are commonly used. Carotin ($C_{26}\ H_{38}$) is easily dissolved by ether but is insoluble in water. The melting point is 167.8C. Concentrated sulphuric and nitric acid color it a dark blue. Its crystals are rhombic. The functions of carotin, according to Kohl, are threefold. First it aids in assimilation. Its absorption bands lie in the blue half of the spectrum, and, together with those of chlorophyll, give the absorption spectra of the crude leaf-green. "Both take an important, though unlike part, in the assimilatory work of the chloroplasts, both absorb supplementarily to each other a part of the sunlight and assist in the decomposition of the atmospheric carbonic acid." Secondly, carotin may serve as a reserve product, as in a number of Fungi and Algæ and in the root of *Daucus carota*. Thirdly, it is of biological importance because it renders flowers, fruits and seeds conspicuous and attractive to insects and birds, which aid in their fertilization and dissemination. Among the flowers which owe their yellow color to carotin are, *Abutilon nervosum*, *Adonis vernalis*, *Cucurbita pepo*, *Eranthis hyemalis*, *Forsythia viridissima*, *Geum montanum*, *Helianthus annuus*, *Impatiens noli-tangere*, *Kerria japonica*, *Œnothera biennis*, yellow flowered roses, *Taraxacum officinale*, and *Tropæolum majus*.

In the peel or pericarp of the lemon, in the flowers of the yellow dahlia, in *Linaria vulgaris*, *Corydalis lutea*, the yellow parts of *Antirrhinum majus*, and in all the yellow flowering thistles, as well as in other flowers, the yellow pigment does not occur in plastids, but dissolved in the cell sap. What is this pigment? In a solution of crude leaf-green, in addition to carotin, there are two other yellow pigments, one of which was obtained by Tschirch in 1896 and the other by Schunck in 1899. Kohl proposes to designate the latter of these two pigments as α-xanthophyll and the former as β-xanthophyll. They differ both in their absorption spectra and chemical reactions. The α-xanthophyll occurs in small quantities in normal chloroplasts and yellow autumn leaves. It is the β-xanthophyll which colors the peel of the lemon and the flowers with yellow cell

sap. Both carotin and β-xanthophyll occur in species of Ranunculus, Verbascum, *Caltha palustris* and *Ribes aureum*. The β-xanthophyll can be obtained in a yellow solution by boiling in water the peel of the lemon. It becomes brown-colored with sulphuric acid and with ammonia a deeper yellow. This pigment was first isolated from the flowers of the dahlia nearly half a century ago.

In the chloroplasts of golden yellow-leaved plants, as Sambucus and Evonymus, Kohl finds yet another yellow pigment largely soluble in water to which he gives the name of phyllofuscin. In addition to this pigment he finds in yellow leaves much carotin, and more or less β-xanthophyll, but no α-xanthophyll or chlorophyll. Though they contain no chlorophyll such plants grow and perform the work of assimilation, in which process the chief part must be ascribed to carotin. Finally in yellow autumn leaves there is little or no chlorophyll, about the same amount of carotin as in the green leaf, little α-xanthophyll and much β-xanthophyll.

The yellow plastids of flowers are usually round and small, though sometimes angular as Tropæolum. Several other modifications also occur. In the tomato, asparagus, *Cratægus coccinea*, and in some species of Rosa and Physalis the plastids of the fruit are spindle-formed or irregularly shaped, and are fire-red, orange-red, or yellowish red. Tammes found that the red plastids of the tomato gave the usual reaction for carotin. In yellow leaves the plastids are round, but in autumnal yellow leaves they occur in irregular masses. The scarlet poppy, tulip and fire red canna owe their colors to a mixture of yellow plastids and red cell sap. On the other hand dingy or dull colors result from a combination of violet sap with yellow granules.

Anthocyan.—The red and blue colors of leaves, fruits and flowers are produced by a soluble pigment termed anthocyan. The ecological significance of this coloring substance, which is widely distributed in plants, is important and deserves further study. It is of frequent occurrence on the stems, veins and leaves of herbaceous plants, as well as on the under side of aquatic leaves and of radical leaves growing in rosettes, as in the Cruciferæ. In early spring, in autumn, and at high ele-

vation, it is particularly abundant. It probably serves to convert light rays into heat, and at the same time protects and aids in the translocation of the food materials. As in the previous instances we have undoubtedly to deal with a group of pigments. The formation of anthocyan has been studied by Overton with the aid of cultures of aquatic and land plants. Experiments with water cultures of Hydrocharis showed that light intensity and low temperature were favorable to the development of red cell sap. Plants of Hydrocharis were placed in a 2% solution of invert sugar, and also in pure water. The conditions of light and temperature were such that the water culture plants showed no change in color, while in a few days the plants in the invert sugar solution developed dark red coloring, especially in the new leaves. Experiments with other aquatic plants gave similar results. The red cell sap was contained chiefly in the palisade cells, though extending also to other cells of the mesophyll. Cut stems of *Lilium martagon* and other land plants placed in a 2% invert sugar solution soon developed red color in the palisade cells. The leaves of the control plants remained a pure green. As the result of many observations Overton concludes that a cell sap rich in sugar, low temperature, and intense light are connected with the production of red color. During the summer in the Alps the leaves of plants are much oftener red-colored than in the lowlands, because the night temperature is lower and the light intensity higher. Winter leaves become red-colored since the lower temperature causes the sugar content of the leaves to increase at the cost of the starch. In the ripening of red and violet-colored fruits the appearance of the coloring is also attended by the conversion of the starch into sugar. A few experiments were made to determine whether white flowering varieties of certain plants could artificially be caused to vary into red flowering varieties, but with negative results. In the case, however, of the greater intensity of color in Alpine flowers, and of white lowland flowers which become red-colored in the Alps, and also of flowers which are brighter colored in early spring than later in the season, it is probable that the lower temperature causes the conversion of starch into sugar.

The red pigment is probably a glucoside, or a very closely related compound, of which the constituents are a sugar and a tannic acid. Since in many plants, the provision of the cells with sugar increases the tendency to form red cell sap, there can be little doubt that a sugar forms part of the raw material out of which the pigment is built up. Tannins are also contained in the cells in which the red color has been formed by the artificial increase of sugar. The red color stuff is thrown down by the tannin reagents coffein and antipyrin, and the precipitate closely resembles those of the tannins. The behavior of the red pigment indicates that it is a tannin compound. The supposition that tannin is connected with the formation of the red and blue pigments of flowers is not new, but was first suggested by Wigand in 1862. It was observed that red color was formed only in cells that contained tannin. "If we examine," says Overton, "the reaction of the red color stuff upon different bases we obtain support for the opinion, that this pigment represents a weak bivalent or multivalent acid. For we find that its tinge is almost unnoticeably changed by very weak bases as coffein, antipyrin, etc., that with stronger bases, however, the color turns first into violet and blue, and with a greater excess of a strong base it finally changes into green. The most simple explanation of these phenomena is that the free acid is only little dissociated electrolytically and that the red color is peculiar to the molecules of the acid that has not been dissociated, the blue color would belong to the univalent, and the green color to the bivalent ions of the acid. On account of the weakness of the acid the bivalent ions would be found — in consequence of hydrolytic dissociation — in larger quantities only when a certain excess of a base is present." The capability of forming red cell sap appears to belong chiefly to the phanerogams, for the red color of mosses is confined to the cell membrane.[1] Many of the pigments found in plants and used for coloring are glucosides. The indigo blue of commerce is derived from the glucoside indican, which occurs in the plants of the leguminous genus Indigofera. Indigo red is also obtained from this gluco-

[1] Overton, E. Beobachtungen und Versuche über das Auftreten von rothem Zellsaft bei Pflanzen. *Jahrb. wissensch. Botanik*, Bd. xxxiii, H. 2.

side. From indigo may readily be obtained aniline remarkable for the great variety of dyes which it yields.

In darkness flowers differ greatly in the extent to which they develop their colors. *Silene pendulata* fails to show red coloring and *Prunella grandiflora* instead of developing dark violet color remains a pure white; while *Tulipa gesneriana* forms its red color and *Crocus vernus* its blue violet as perfectly in darkness as in light. The explanation given by Sachs, where bulbous plants produce normal flowers in darkness, is that the flower forming substance was already collected in the bulb, and had been stored up in a preceding period of vegetation in bright sunlight. Leaves, flowers and fruits often display red coloration only on the side exposed to direct sunlight. Kerner found that the anthocyan in plants grown in an Alpine garden at an elevation of 2195 metres above the level of the sea was brighter colored and more abundant than in the botanical garden at Vienna. At a high elevation the glumes of grasses, the leaves of stonecrops, and the pure white petals of some flowers become red or purplish-red.

When a red flower or a solution of red cell sap is treated with an alkali it changes to blue, but the red color is again restored by an acid. Red color is more common in foliage (where it is termed erythrophyll) than blue because an acid condition usually prevails in the leaf cells. In the Boraginaceæ with a decrease in the acidity of the cell sap the flowers change from red to blue; while an increase in the acidity of the cell sap will cause a normally blue flower to vary into a pink variety. "In some rare instances the blue pigment occurs in a solid form in flowers and also in fruit." In the fruit of the nightshade *Solanum americanum* the coloration is due to intense violet-colored crystalloids of rhombic form or in thin six-sided plates.[1] Blue grained pigments also occur in *Strelitzia regina, Tillandsia amœna*, and in *Delphinium elatum*.[2] The occurrence of blue pigment in solid form is probably to be explained by the evaporation of the free water. It never occurs in chromoplasts. Cells containing red and blue sap may occur indiscriminately

[1] Möbius, M. *Die Farben in der Pflanzenwelt*, p. 15.

[2] Hildebrand, Friedrich. *Die Farben der Blüthen*, p. 45.

near each other in the same flower, or the epidermis may contain blue cells beneath which in the mesophyll is a layer of red cells, as in *Viola odorata*.[1] Yellow chromoplasts and anthocyan occurring together give scarlet hues. The shades of flowers depend upon the density of the chromoplasts, and the number of layers of pigment cells, and the character of the epidermis.

Green Flowers.— Of the 223 green flowers classed as entomophilous many have no petals, as fifteen species of the Polygonaceæ and eight species belonging to the Caryophyllaceæ, also in several Rosaceæ, in *Acer saccharinum* and *Didiplis diandra*. Many are self-fertilized, as Triglochin and Scheuchzeria, and the orchids *Habenarea hyberborea* and *Epipactis viridiflora*, and the small green flowers of Lechea and *Penthorum sedoides*. Some have the petals caduceous and depend upon their scent to attract insects, as the Vitaceæ. Many are visited by flies and the smaller bees, as various Melanthaceæ, the Smilaceæ, the Anacardiaceæ, and the green flowers of the Asclepiadaceæ. But the green flowers of Asparagus are visited by the honeybee. As a whole, green flowers are small or even minute and attract few insects. A transition stage is represented by the genus Ribes, which contains species with greenish, white, reddish, and yellow flowers. As is well known many flowers pass through a green stage before their bright colors appear. Large green flowers, which are chiefly fragrant and nocturnal, are found in exotic Solanaceæ. Other examples are exhibited by the orchids, as several Brazilian species of Epidendrum. Green flowers, except in some cases of retrogression, belong to an early stage of development and their coloring requires no special explanation. The petals are modified leaves, and their primitive color is green similar to that of foliage. The larger green flowers may be explained by the greater persistency of the chlorophyll, for some species hold their colors much more strongly than others.

Yellow Flowers.—The development of bright coloration in flowers is an acquired habit. This is well illustrated by the sepals of *Helleborus niger*, which at first are large and white, but after fertilization develop chlorophyll, become a fresh green color and

[1] Möbius, M. *Die Farben in der Pflanzenwelt*, p. 3.

act as leaves. A similar change has been observed in many orchids and liliaceous plants. Virescence, or the occurrence of green flowers instead of those of the normal color, has been observed in many Ranunculaceæ, Umbelliferæ and Compositæ.[1] The formation of chlorophyll has but to cease, and under the action of light the petals will quickly lose their green color, with the result that in most instances the flower will change to yellow or white. If the yellow pigments, which are invariably associated, as has been shown, with the chlorophyll in the chloroplasts are persistent and continue to increase, the color of the flower will be yellow. The quantity of yellow pigments, it will be remembered, varies greatly in different plants. In some they are scarcely perceptible, in others they are so abundant as to tinge the whole plant yellow, while in a few golden yellow species they exclude all other pigments even the chlorophyll. If, however, the yellow color also vanishes we have a white flower. As would be expected yellow and white flowers are the most common, and are the earliest of the floral colors in their origin. A large number of yellow and white flowers with a mostly small, regular and primitive perianth occur in widely separated families.

Families.	Yellow.	White.	Green.	Red.	Purple.	Blue.	Total.
Melanthaceæ . .	7	10	5		2		24
Liliaceæ	6	13	1	11	1	6	38
Polygonaceæ . .	5	22	33	11	3		74
Ranunculaceæ . .	38	26	6	3	13	11	97
Cruciferæ . . .	46	54	2	1	10		113
Saxifragaceæ . .	6	30	4		3		43
Rosaceæ	39	35	4	13	4		95
Onagraceæ . . .	24	14	3	10	6		57
Umbelliferæ . .	16	58			1	3	78
Primulaceæ . . .	11	4		7			22
Solanaceæ . . .	21	9			2	8	40
Cichoriaceæ . . .	53	8		5	2	5	73
Compositæ . . .	209	126	21	4	64	59	483
Total . . .	481	409	79	65	111	92	1237

Many species of Compositæ, it will be noted, retain their primitive colors. In a few families white flowers occur unaccom-

[1] Masters, M. T. *Vegetable Teratology*, p. 339.

panied by yellow. In the aquatic Alismaceæ the entire nineteen species are white, and in the Caryophyllaceæ there are fifty-six white flowers but no indigenous yellow species. The six species of the Xyridaceæ on the other hand all produce yellow flowers. In the anemophilous Betulaceæ there are eleven yellow species, but flowers with a yellow calyx are rare in the Apetalæ. The Hypericaceæ are nearly monochromatic as twenty-two species are yellow and only two red. The zygomorphic Orchidaceæ contain ten yellow-flowered species, a larger number than any other monocotyledonous family. A surprisingly large number of yellow flowers occur in the zygomorphic Papilionaceæ (33 species), the Scrophulariaceæ (33 species), and the Lentibulariaceæ (11 species). This fact Müller attributes, and we think rightly, to the persistence of the primitive yellow in certain genera, and its little tendency to variation with the specialization of the flowers. In many families of the Gamopetalæ yellow flowers are absent, or are represented only by a single species, as in the orders Ericales, Ebenales, and Gentianales, where the inflorescence is chiefly white or red.

White Flowers.— White flowers are most abundant in the American as well as in the European flora. A white inflorescence is evidently a less tax on the energies of a plant than one containing pigments; and trees and shrubs, which produce their flowers in almost boundless profusion, as the Pomaceæ, Drupaceæ, Ilicaceæ, and the genus Viburnum, have almost exclusively white blossoms. In the writer's opinion white flowers are primarily due to degeneration. In this connection the studies of white leaves by Rodrique, Laurent and Timpe, which clearly show evidences of degeneration, are of interest. According to their investigations such leaves are thinner than normal green leaves, and consist wholly of cellular tissue with the palisade cells absent. It is desirable to consider very briefly some of the conditions under which white flowers occur, and under which they develop chromatism. They are derived both from primitively green and from high colored flowers. Small, densely clustered white flowers are common in the Cruciferæ, Saxifragaceæ, Umbelliferæ, Cornaceæ and Ericaceæ. In these flowers the stimulus to produce pigments is wanting and the leaf-green

colors, as may be observed in the Cornaceæ, fade away leaving the petals white. A check in nutrition and growth will cause bright colored flowers to become smaller and revert to white. This may be caused by cultivation in an impoverished soil, by transplanting, or by low temperature. In springtime white flowers are noticeably common. In the Baltic flora the graphic curve of white reaches its highest point in May, from which it gradually sinks to its lowest point in late autumn. In the arctic climate of Spitzbergen the flowers are chiefly white, and there are few yellow and red, while blue appears to fail entirely. In East Greenland the flowers are likewise chiefly white, and among twenty-six species there is only one blue.[1] Self-fertilization also causes a diminution of the corolla in size and a paleness or loss of color.[2] Bright colored flowers fertilized artificially with their own pollen in a few generations become paler; while white flowers, as would be expected, and what is more surprising white varieties of colored flowers adapted to insect-fertilization, are both usually self-fertilizing. They may also exhibit evidences of deterioration in their structure, as in Lepidium, Stellaria, and Sagina, where the petals are usually present but sometimes are wanting. In all of the instances cited there is a lack of vitality in the corolla due to insufficient nutriment. Let the growth of the plant now receive a stimulus and an increased brilliancy of the flowers soon makes itself apparent, as when they are exposed to clear sunlight or treated with nitrate of soda, and may also be observed in the flushing of tulips, by which they lose their variegated colors when treated with strong manure. The brightness of the floral hues is also increased by crossing. When a white flower is crossed by a yellow, red, or blue flower, a part of the hybrid offspring contain pigments. When lowland white flowers have been cultivated in the intense light of alpine heights, they have in some species become red. Though the conditions are abnormal a rapid development in size and color in an individual flower may be caused by the sting of a gall-fly; for example, all of the organs of *Cratægus coccinea* become bright red and the change of coloring is accompanied by an increase in size.

[1] Hildebrand, F. *Die Farben der Blüthen*, p. 70.

[2] Henslow, G. *On the Self-Fertilization of Plants*, p. 327.

The appearance of bright coloration is here marked by an increased protoplasmic activity.

This view of the origin of white flowers explains why they are commonest in Nature, accounts for their being most numerous in families in which yellow flowers are likewise numerous, and why they are most true to name under cultivation. We can also understand that such flowers under forcing would be more likely to develop a desired color than one already containing pigments.

Red Flowers.— From its wide distribution among plants red coloring naturally follows yellow and white in flowers. Light which is destructive of chlorophyll stimulates the formation of anthocyan. With the increase of white flowers in size and vitality, accompanied by an increase of the sugar content,[1] they very frequently develop red coloration. In the Rosaceæ and Pomaceæ a series of flowers illustrates every step of the transition from white to red. The species of Rubus and Cratægus are usually white or occasionally red, but *Rubus odoratus* is purple red with a white form. In the familiar genus of Malus the species are tinted or strongly shaded with rose, which in the fragrant flowers of *M. coronaria* becomes the predominant color. In Rosa the species are regularly rose or pink varying in several species to white. Red flowers are derived often from white, sometimes from yellow, and occasionally by reversion from blue. They are the rarest in our flora. There are twenty-two species in the Monocotyledons, forty-five in the Apetalæ, eighty-four in the Polypetalæ, and one hundred and six in the Gamopetalæ. Red flowers occur both in the older and more recently evolved families, while blue flowers are restricted to the latter. Red coloration must be regarded of earlier origin in the sequence of floral colors than blue; and, as has been already pointed out, it is also much more common in the vegetative organs of both the angiosperms and cryptogams. In the following families red and blue and blue-purple flowers are the most common:

[1] It is not unlikely that the higher intensity in color of Alpine flowers is due to an increase of the sugar content, but, according to Overton, in most cases of white-flowered varieties it is probably that some other compound rather than a sugar is wanting.

Families.	Red	Blue.	Purple.	Yellow.	White.	Green.	Total.
Liliaceæ	11	6	1	6	13	1	38
Orchididaceæ . .	8		14	10	18	11	61
Polygonaceæ . .	11		3	5	22	33	74
Caryophyllaceæ .	22		2		56	8	88
Rosaceæ	13		4	39	35	4	95
Papilionaceæ . .	13	24	88	33	39		197
Malvaceæ . . .	13		4	5	4		26
Onagraceæ . . .	10		6	24	14	3	57
Ericaceæ	10		5	22	1		38
Vacciniaceæ . . .	11				10	2	23
Gentianaceæ . .	10	16	4	1	7		38
Polemoniaceæ . .	10	8	3		7		28
Labiatæ	12	33	47	4	24		120
Total . . .	154	87	181	149	250	62	883

It is evident that the families containing red flowers may be separated into two series. In the first, which includes the Polygonaceæ, Caryophyllaceæ, Rosaceæ, Malvaceæ, Onagraceæ, Ericaceæ, and Vacciniaceæ, there are red flowers but no blue. These families are primitive with regular flowers, which are frequently of small size and but little modified. The Orchidaceæ offer an exception in which, however, though there are no blue, there are fourteen purple flowers. In the second series, which includes the Liliaceæ, Papilionaceæ, Gentianaceæ, Polemoniaceæ, and Labiatæ, there are both red and blue flowers, which are highly specialized and often dependent on insects for fertilization. Purple flowers belonging to the first series are chiefly red-purple, while those of the second are blue-purple. The Rosaceæ and Papilionaceæ are "sister families," according to Engler; both contain red flowers but there are no blue flowers in the Rosaceæ though they are numerous in the Papilionaceæ. The distribution of the red and blue coloration is probably to be explained by the strong acidity of the cell sap in the first series, and its more nearly neutral condition in the second, so that a comparatively slight variation in the chemical conditions permits the development of either a red or blue flower. A part of the hybrids obtained by Darwin by crossing the red and blue species of Anagallis were red and a part blue, while others were intermediate in color. The same observer also records having seen

a hyacinth with a truss of flowers perfectly blue on one side and perfectly red on the other. Several of the flowers were also striped longitudinally red and blue.

Anthophæïn. — In most instances the brown colors of flowers are caused by a mixture of chlorophyll or carotin with anthocyan. Among brown flowers containing two pigments are *Calycanthus floridus*, *Veratrum nigrum*, *Aristolochia glauca*, *Anona triloba*, Asarum, *Adonis vernalis*, *Ribes grossularia*, and various species of orchids. But in the black spots and brown markings on the flowers of *Vicia faba* and of some species of Delphinium, Möbius finds an olive brown pigment dissolved in the cell sap.[1] As its chemical reactions and optical properties are sufficiently characteristic to distinguish it from other plant coloring substances he proposes for it the name of anthophæïn. The spots on the wings of *Vicia faba* appear black largely because of the papilla-formed structure of the epidermal cells, which become flatter where the markings are brown. The properties of anthophæïn are very similar to those of phycophæïn, the pigment peculiar to the brown Algae ; but it differs from this substance in that it is dissolved in the cell sap, while phycophaeïn, together with chlorophyll, occurs in chromatophores. It is also less soluble in water. Phycophæïn is characteristic for an entire class of plants, while flowers containing anthophæïn are rare.

Purple Flowers. — There are twenty-two purple flowers in the Monocotyledons, twenty-four in the Apetalæ, one hundred and ninety-three in the Polypetalæ, and one hundred and ninety-eight in the Gamopetalæ. Purple flowers may be divided into green or lurid purple, red purple, and blue purple. In the Melanthaceæ there are two small greenish-purple flowers adapted to Diptera. In Trillium of the Convallariaceæ are four lurid purple flowers visited by flies. In the Aristolochiaceæ which are also adapted to Diptera the calyx is lurid purple. These flowers appear to have been derived directly from the primitive green without passing through an intermediate stage. Greenish-purple flowers also occur in the Polygalaceæ and Asclepiadaceæ. Numerous other families contain a few small purplish flowers, which evidently

[1] Möbius, M. Das Anthophæïn, der braune Blüthenfarbstoff. *Berichte deutschèn botan. Gesell.* Bd. xviii, p. 341.

belong to a primitive stage of coloring. There are a few flowers which are yellowish-purple. The petals of *Asinima triloba* are at first greenish-yellow changing to a dull purple. In *Geum rivale* the petals are purplish-orange and the calyx brown-purple. Red-purple flowers belong to a higher stage of coloration. They are common in the Orchidaceæ, Geraniaceæ, Lythraceæ, and Onagraceæ. Blue-purple are the most advanced of all, and are common in the Papilionaceæ, Labiatæ and Scrophulariaceæ, families which contain numerous blue bee flowers, to which they are akin in form and color. Many purple flowers also occur in the Compositæ which are partly discoid and partly radiate. Except in a few species where the color stuff is the rare olive brown anthophæin, brown and brown-purple flowers usually contain more than one pigment.

Blue Flowers. — There are only thirty-four blue flowers in the monocotyledons of the Northern States, which belong chiefly to the Commelinaceæ, Liliaceæ, and the Iridaceæ. In the Apetalæ there are no blue flowers, and the purple flowers in this series are primitive in their stage of coloring. The rarity of blue flowers continues in the Polypetalæ. They are most common in the Ranunculaceæ, Papilionaceæ and Violaceæ. In the more primitive families of the Gamopetalæ belonging to the orders Ericales, Primulales and Ebenales blue flowers are again absent. They belong chiefly to the three orders, Gentianales, Polemoniales and the Campanulales. It is, however, in the Polemoniales that blue and blue purple species reach their maximum. There are many bee flowers greatly modified both in form and color and displaying a high degree of variegation. The culmination of color specialization, as has been previously shown in detail, is reached in this order. It will be observed that blue flowers occur almost exclusively in the most specialized families, or when they are present in a more primitive family, as in the Ranunculaceæ, it is in genera which have been highly modified, as in Delphinium and Aconitum. These families and genera are the most recent in their evolution, and blue is consequently the most recent of the floral colors to be developed. Blue flowers are usually derived from red or white forms, but in several families they appear to have yellow-flowered ancestors. Müller believed

this to be the case in the Violaceæ and in Gentiana and in *Myosotis versicolor*. The sequence of the floral colors has been determined by the properties and distribution of the plant pigments, rather than by the selective influence of insects.

Two Color Series. — The colors of flowers may be divided into two series, a primitive series consisting of green, white and yellow, and a derivative series composed of red, purple and blue. In the first the pigments are insoluble and are contained in plastids or are absent. In the second they are dissolved in the cell sap. Of the 4020 northern angiosperms 3001 belong to the first series, while 1019 belong to the second. Of the 2972 entomophilous species 1968 belong to the first and 1004 to the second series. The flowers of the second series are far more numerous in the Polypetalæ and Gamopetalæ than in the Monocotyledones and Apetalæ. The pigments of the first series are most common in primitive families, where the flowers are rotate and but little modified. Very many flowers of the second series have the petals green, whitish, or yellowish in the bud or at the base. In the color changes which takes place in individual flowers green may be succeeded by every color, and red and blue frequently pass through a white or yellow stage. In individual flowers the tendency of green, white, and yellow to change to red and blue is much stronger than the reverse.

Pigments not Induced by Insects.— The function of forming pigments has not been induced by insects. It is a property possessed by all plants from the lowest to the highest. Not only chlorophyll but carotin and other pigments are widely distributed among the algæ. This function is fully developed even among minute unicellular plant organisms. The chromogenous Bacteria are capable of producing colors of remarkable intensity, as red, rose, yellow, orange, green, blue, violet, and black. Four different pigments, as black, blue, green, and yellow, are produced by the *Bacillus pyocyanus*. The red of *Micrococcus prodigiosus* can be extracted by alcohol, discolored by alkalies and restored by an acid. Intense light and acids in small doses increase the production of the pigments, and the alkalies have the reverse effect.[1] Bohn considers the study of Bacteria as

[1] Bohn, G. *L'Evolution du Pigment*, p. 44.

of much interest from their supposed similarity in origin and composition to the pigment granules. According to this author the chromoplastids have their origin in the nuclear chromatin, and are designed to protect the organism from the chemical and physical variations to which it is exposed. A remarkable difference is exhibited by plants in their capability of forming pigments. The four great divisions of the Algæ are characterized by the presence of a green, blue, brown, or red pigment, which in the last three classes is so abundant as to completely mask the chlorophyll. The Fungi display many brilliant colors, which in the Phalloideæ become ecologically important, and prophetic of their attractive office among the Phænogams. In this family flesh flies are allured by the bright coloring, associated with a sweet substance and a nauseous scent, and aid in disseminating the spores. In their form and vivid colors the Balanophoraceæ show a marked resemblance to Fungi. Many conifers and deciduous shrubs and trees display a bright yellow foliage, from which chlorophyll is absent. There is also a great variety of trees and shrubs and herbaceous plants both in tropical and temperate regions, which possess a red, purple, or variegated foliage, which is highly ornamental. Conversely many pale green species exhibit scarcely a trace of bright coloration. The petals are only modified leaves and their colors are closely correlated with the coloration of the vegetative organs. It is often possible from the inspection of the stem and leaves of a plant to determine the color of the flowers it will produce.

Of no Physiological Significance. — With the exception of chlorophyll the pigments are of no physiological significance in the development of flowers. Their function is wholly ecological, and any other effect they may produce is slight and incidental. Negative evidence of this is furnished by the great number of white flowers. Red and blue coloring frequently does not appear until the flower is on the point of expanding. And even after fertilization or in wilting the colors may brighten or change. Bright coloration in flowers, as in fruits, marks the approach of maturity and decay. According to Massee many of the beautiful colors of fungi are of no obvious use.[1]

[1] Massee, G. *Evolution of Plant Life*, p. 145.

Conspicuousness Due to Insects. — Bright coloring in flowers, usually accompanied by an enlargement of the perianth, has been evolved through the agency of insects. Wind-flowers are small and green or dull colored. "In New Zealand where insects are so strikingly deficient in variety, the flora is almost as strikingly deficient in gaily-colored blossoms."[1] In many genera as the flowers become more conspicuous, there is an increase in the number of visitors and the power of self-fertilization is lost. A colored perianth, which contrasts strongly with the surrounding green foliage, can evidently be more easily seen by both insects and birds. For the same reason a contrast in color between different species in blossom at the same time is advantageous. Insects would be likely to make their visits indiscriminately in a monochromatic Flora, as now happens in the case of similarly colored species of buttercups and goldenrods. In the Alps, where owing to the shortness of the summer all of the species blossom at the same time, there is the greatest variety of colors. It is a well known principle of physics that when a red and yellow card are placed side by side each appears more brilliant than when viewed alone, that is the effect of bringing two colors not complimentary in competition is to move them farther apart.[2] The utility of color contrast is sufficient to explain the evolution of floral colors without recourse to the hypothesis that they afford pleasure to insects.

Insects and Flowers.— The influence of insects upon the evolution of flowers has undoubtedly been greatly overestimated. There is certainly no satisfactory evidence that the ancestors of all angiospermous flowers were once entomophilous, and that the wind-fertilized forms are the result of degeneration. In my opinion not only the principal plant series but many families and genera were developed before the habit of flower visiting became established. The formation of this habit must have required a considerable interval of time. Neither is there sufficient evidence to support the claim that the color of every flower has been determined by the pleasure it afforded to the pollinating insects.

[1] Thompson, George M. Fertilization of New Zealand Flowering Plants, *Trans. Proc. New Zeal. Inst.* 1880. Opinion of A. R. Wallace.

[2] Rood, O. N. *Text-Book of Color*, p. 246.

Some of the adherents of this theory have not, however, hesitated to cause a flower to undergo several changes of color in order that its present hue may conform to their imaginary views of its origin. Further observations are required to determine how far a sense of color is developed among insects, but the writer believes that the colors of flowers have determined the color sense of insects rather than the converse. It is desirable to review briefly the evidence of a preference for certain floral colors in the four orders of insects,— the Coleoptera, Diptera, Lepidoptera, and Hymenoptera,— which are important as flower visitors.

Coleoptera. — There is no evidence that the Coleoptera have exerted any influence on the particular coloration of flowers. They are often poorly adapted for flower visiting, a habit which they have acquired at a comparatively recent date. They probably give the preference to bright colors, but they do not avoid dull yellow or green. None of our northern species are adapted to Coleoptera, but they are very frequent visitors to rotate clustered white flowers like Viburnum. No inference can be drawn from the beautiful markings often displayed by beetles that they take pleasure in the colors of flowers, for the most intelligent of all flower visiting insects, the bees, wear the plainest dress.

Diptera. — The Diptera as fertilizers of flowers are of much greater importance than the Coleoptera. The Syrphidæ have been thought to hover with delight over bright golden yellow flowers; while the carrion flies, it has been asserted, are attracted by a lurid red or purple inflorescence. In number and importance as flower visitors the Syrphidæ, or drone flies, surpass all other Diptera. The light blue *Veronica chamædrys*, the rose pink *V. urticifolia* and the white *Circæa Lutetiana* are adapted to these flies, but they certainly furnish no evidence that their colors have been evolved by their selective influence. Plateau has recently shown that the Syrphidæ poise before many inconspicuous objects as green flowers, closed buds, green fruits, or even the point of the finger, in the same manner as before yellow flowers. Poising upon the wing before a flower must, therefore, be regarded merely as a habit of flight, and not as evidence that pleasure is experienced. It is, however, probable that as

yellow is the color of honey and pollen the more acute insects may from long experience, as in the case of yellow honey-guides, associate this color with the presence of a supply of food. Another group of flowers have nauseous or indoloid odors due to the decomposition of some nitrogenous compound. They are often flesh-colored, blood red, dull dark purple or red, and sometimes they are marked with livid stripes or spots. By some authors they are regarded as resembling putrifying flesh or decaying carcasses. In most instances the resemblance is not very apparent. Malodorous flowers with other colors as yellowish green or white also occur. These flowers are visited by carrion and dung flies belonging to such genera as Musca, Lucilia, Sarcophaga, and Scatophaga, which are believed to find the supposed resemblance to putrid substances attractive. While there is no improbability in this supposition, it is chiefly, if not entirely, the nauseous odors which attract these insects. The lurid coloring may often be explained by peculiarities of the plants in the production of pigments, as in the Balanophoraceæ, where not only the inflorescence but the whole plant is vividly colored. There are also a large number of flowers with strong scented rather than repulsive odors, which are attractive to flies, as *Anethum graveolens* and some Umbelliferæ.

Lepidoptera. — Various birds and mammals, as is well known, become greatly excited when a red object is held before them. Humming-birds and honey-suckers are attracted by fire-red and scarlet colors. Kerner has pointed out that flowers of these colors are more abundant in the Tropics and in South Africa, where these birds are most numerous; while they are rare in Europe where there are no humming-birds. There would seem to be no *a priori* reason why butterflies, as Müller believed, may not be strongly influenced by red coloration. Of eight Alpine butterfly flowers (*Orchis globosa*, *Lilium martagon* and *L. bulbiferum*, *Gymnadenia odoratissima*, *Dianthus superbus*, *D. silvestris*, *D. atroruber* and *Daphne striata*), all were red colored. Other red butterfly flowers are species of Silene, Lychnis and Primula, *Erica carnea*, and species of Asclepias and Monarda. On the other hand three species of Globularia with light blue flowers are adapted to butterflies, "the only instance in the

German and Swiss flora of a blue color being produced by the selective agency of Lepidoptera." That butterflies visit very frequently flowers of a great variety of colors is well known to every observer. Of 1432 visits made by 100 species of Rhopalocera, 44.8% were made to greenish-yellow, yellow and white flowers; and 55.2% to red, violet, and blue flowers.[1] The percentage of visits to wasp and bee flowers was 16.7%, and to lepidopterous flowers 13.8%; but the greatest number of visits was to flowers of the type of the Compositæ which was 43.2%. The percentage of visits to flowers with the honey exposed or not deeply concealed was small. Essentially the same results were reached by the comparison of 2086 visits of 220 Lepidoptera. The above figures show that butterflies are influenced more by the form of the flower than by its color. Red and blue flowers are usually tubular and contain more honey than yellow and white flowers, which are more often rotate and exposed to pillagers of every sort. The flat, capitate inflorescence of the Compositæ is especially well adapted to butterflies. It is also noteworthy that in the families and genera, which contain red-colored butterfly flowers, blue is very rare or wholly absent. The evidence that red floral coloration is a source of pleasure to butterflies cannot be regarded otherwise than unsatisfactory. Nocturnal Lepidoptera are attracted by brightness, as white or yellow and especially a bright light, rather than by hue.

Hymenoptera. — By putting different colored papers over the entrance holes of ground wasps it has been proven that wasps can quickly distinguish between colors.[2] By a series of well-known experiments Lubbock also showed that different colors were readily recognized by the honeybee. Müller as the result of numerous observations came to the conclusion that the honeybee prefers blue, violet, and various shades of purple and red, to white and yellow and avoids scarlet and lurid colors. During the past summer I repeatedly observed the honeybee collecting pollen on the flowers of the scarlet poppy; and am led to believe that, if these flowers contained nectar, the color would not pre-

[1] Müller, H. *Alpenblumen*, p. 523.

[2] Morely, Margaret. *Wasps and their Ways*; Peckham, G. W. and E. G. Some observations on the Special Senses of Wasps, *Proc. Nat. Hist. Soc. Wisc.*, 1887.

vent the frequent visits of bees. Like butterflies bees are greatly influenced by the form of the flower. The long-tongued bees seldom visit butterfly flowers, pollen flowers, and flowers with the honey fully exposed unless it is very abundant. They are most frequently collected on wasp and bee flowers, and on associations of flowers with the nectar deeply placed. The percentage of visits made by the long-tongued bees to yellow and white flowers in Müller's observations was 36.6%, and to red and blue 63.3%; while the percentages of the short-tongued bees were almost exactly the reverse, or 63.8% to yellow and white, and 36.2% to red and blue flowers. This difference seems to be chiefly due to the form of the flowers rather than to their color, as the short-tongued bees are largely excluded from flowers with the honey deeply concealed. The evolution of bee flowers and that of the long-tongued bees has gone on *pari passu*. The progenitors of the bee flowers were presumably regular, and mostly white or yellow; while Apis, Bombus and the allied genera are descended from forms resembling Prosopis. As the perianth gradually became specialized a whole host of pillaging flies and beetles were shut out, and a more abundant supply of honey remained for the rightful visitors. If these partially developed bee flowers displayed red or blue colors, they would be more easily distinguished by the lawful guests from the great mass of blossoms with the honey unprotected. As the result of long experience the more intelligent bees would learn to associate these colors with an ample supply of food and freedom from unwelcome competitors. White and yellow flowers would tend to disappear in these genera. A preference for blue coloration shown by bees at the present time does not, therefore, necessarily imply that blue affords them an æsthetic pleasure; but only that they recognize the signal of flowers adapted to their visits.

Conclusion. — The colors of flowers both in general and particular have been determined by their utility rather than by an æsthetic color sense in insects. Insects distinguish between different colors, but they do not receive greater pleasure from one hue than from another. Any preference they may manifest has arisen from the association of the colors with the presence of food substances. Conspicuousness, or contrast of the inflores-

cence with the foliage, has been induced by insects. It is of advantage to insects since it enables them to find nectariferous flowers quickly, and to plants because it aids in securing cross-fertilization. Many colors are better than one since the flowers are rendered more conspicuous by contrasts with each other as well as with the foliage, and insects are less liable to visit them indiscriminately. The sequence of colors, green, yellow, white, red, purple, and blue depends upon physiological causes. Plants vary greatly in their capability of forming the different kinds of pigments, and the floral colors are correlated with the variability of this function. The primitive colors green, yellow and white have been determined by the nature of the chloroplast and its pigment content; while red, purple and blue have arisen as the result of various chemical and physical conditions.

Bibliography. — In the preparation of these papers constant use has been made of the works of Müller, Knuth, Kerner, and Darwin; of the Manuals of Gray and Chapman; and of the *Illustrated Flora* of Britton and Brown. Bibliographies of the literature dealing with the mutual relations of flowers and insects and with the colors of flowers will be found in Müller's *Fertilization of Flowers*, translated by D'Arcy W. Thompson, and in Knuth's *Handbuch der Blütenbiologie* (2871 titles). References to 772 books and papers on plant pigments are given in Kohl's *Carotin und seine physiologische Bedeutung*. In his paper "Beobachtungen und Versuche über das Auftreten von rothem Zellsaft bei Pflanzen" Overton briefly reviews the literature relating to anthocyan. For the literature on the colors of animals Newbigin's *Color in Nature* may be consulted.

WALDOBORO, MAINE.

RIB VARIATION IN CARDIUM.

FRANK COLLINS BAKER.

CONTENTS.

I. Introduction. II. Material. III. Method of obtaining quantitative data. IV. Discussion of data. *Cardium robustum. Cardium isocardia. Cardium muricatum.* V. Comparison of the three species.

I. INTRODUCTION.

AT the present time biologists and zoölogists are paying marked attention to the study of the laws of variation, such studies having a strong bearing upon the origin of species. The results of such studies will be of little value, however, unless great care is taken in recording the exact locality from which the material came. And likewise the results will be *nil* unless the material studied is of such a quantity as to form a good basis for a quantitative examination. It frequently happens that a careful study of the variation of a certain species is rendered valueless because the working material has been too limited in quantity.

That the time expended in such study is well spent is clearly shown by the following statement made by the late Prof. Edward D. Cope.[1]

"So soon as sufficient material becomes available, the zoölogist can make that kind of research into the permanency and variability of the characters of species which characterizes the exact stage of the science. It is on such study that all useful conclusions as to the origin of species depends. It is not the orderly relation of species and genera to each other that demonstrates the truth of the hypothesis of the derivation of the

[1] As quoted by C. C. Adams, p. 208.

species, but the knowledge of their variations. Moreover, the beginning of all investigation into the causes of those variations is the knowledge of the direction which they take, whether they are promiscuous or whether they bear some definite relation to each other or to the environment."

The following paper is a contribution to the study of variation in the sculpture of the pelecypod Mollusca, as shown in the genus Cardium.

II. MATERIAL.

The material upon which this paper is based consists of three species of Cardium; *C. robustum*, *C. isocardia*, and *C. muricatum*. They were collected by Dr. J. W. Velie and W. W. Calkins on the west coast of Florida, near Tampa. Several hundred specimens of each species have been examined, thus affording enough material for a wide range of variation. To this material is added some data gathered by Dr. W. H. Dall and published in his "Contributions to the Tertiary Fauna of Florida."

III. METHOD OF OBTAINING QUANTITATIVE DATA.

The ribs on each valve were carefully counted and in order to remove any possibility of error they were recounted several times at intervals of two or three days. The size (length) of each shell was determined by a pair of calipers spread from the umbones to the ventral margin. These measurements are all in millimeters.

In the curves plotted, the groups or classes having the same number of ribs are indicated on the horizontal line, and the number of specimens in these groups, the frequencies, are noted on the vertical line.

In the tables the number of ribs is indicated as a numerator, and the individuals having the same number of ribs is noted as a denominator.

IV. Discussion of Data.

Cardium robustum. (= magnum.)

Figures 1 and 2.

Table A.

30	31	32	33	34	35	36	37
1	33	77	128	81	39	3	2

Number of shells examined 364. The range of variation is from 30 to 37.

The mode, or class with the largest number of individuals, is 33, with a frequency of 128. This curve is remarkable for its regularity and for its strong monomodal tendency.

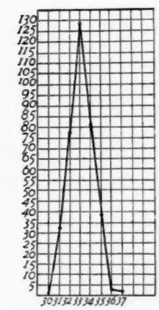


Fig. 1. *Cardium robustum.* Variation curve of 364 specimens.

In counting the ribs of this, as well as of other species, it was noted that the variation was confined almost wholly to that part of the shell anterior or in front of the umbonal ridge, the latter being strongly indicated by a large, heavy rib extending from the umbones to the ventral margin, and separating the flat posterior slope from the rounded anterior and lateral slopes.

There is one more rib on one valve than on the other in this region, the numbers being 7–8, or 8–9. The ribs of this area were carefully counted and the following result obtained, the figures being for the maximum number of ribs: $\frac{7\text{–}8}{355}$ $\frac{8\text{–}9}{9}$. This gives the normal or mode at 7–8, with a frequency of 355. If this were plotted on a diagram it would give a very sharp, narrow curve, which always stands for stability. It is also noteworthy that the curve for all the ribs and that for the ribs posterior to the umbonal ridge are similar in form. The size of the shell apparently does not change the result of these calculations. 41 specimens measuring 90 millimeters gave the result shown in figure 2 and in the following table:

Table B.

31	32	33	34	35	36
1	14	15	8	2	1

As in table A the mode is at 33 (frequency 15) with an additional minor mode at 32 (frequency 14). This indicates a larger amount of variation for the 90 millimeter individuals than for the whole number of specimens, and illustrates the value of examining a large amount of material in order that a false impression may not be given by the curve.

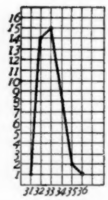


FIG. 2. *Cardium robustum*. Curve of 41 specimens, 90 millimeters long.

Dall[1] has examined a number of specimens of this species and the results are interesting. He found the range of variation to be from 30 to 35, forty-five specimens being counted. Dall remarks that there is a slight tendency to fewer ribs in the southern than in the northern individuals of this species. It would be interesting to have a large number of specimens from different localities examined and plotted, to ascertain the exact amount of this variation.

Cardium isocardia.

Figures 3 and 4.

Table C.

27	28	29	30	31	32	33	34	35	36
3	12	22	73	70	24	13	3	1	1

Number of shells examined 222. The range of variation is from 27 to 36. The mode is at 30 with a frequency of 33 and a minor mode at 31 with a frequency of 70. The noteworthy feature of the curve of *isocardia* is the polygonal instead of the triangular form and the marked symmetry of the two sides.

A comparison of the curves obtained from an examination of

[1] Dall, W. H. Contributions to The Tertiary Fauna of Florida. *Trans. Wagner Inst. Sci.*, Vol. III, part V, p. 1099.

different sized shells is interesting, and is shown in figure 4 and the following table:

Table D.

Size in millimeters.	28	29	30	31	32	33	34	35
30.		4	12	6	4	3	1	1
40.	6	3	16	16	5	3		
50.			5	14	4	4		

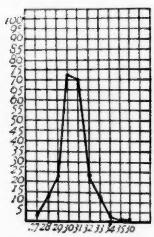


FIG. 3. *Cardium isocardia.* Variation curve of 222 specimens.

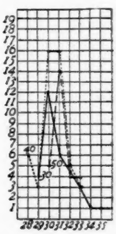


FIG. 4. *Cardium isocardia.* Variation curve of size.

The number of shells examined of the 30 mill. individuals was 31. The range of variation is from 29 to 35, with a mode at 30 and a frequency of 12. Of the 40 mill. individuals 49 species were examined. The range is from 28 to 33, with a double mode at 30 and 31 and a double frequency of 16. The 50 mill. individuals included 27 specimens. The range is from 30 to 33, with a strong mode at 14. The range of variation in the 30 and 50 mill. specimens is very uniform and the curves are almost identical. In the 40 mill. individuals there is more variation as shown by the broadness of the curve and its irregularity at the lower part. This wider range of variation may account in a measure for the polygonal form of the curve for the total number of specimens.

The ribs of *isocardia* are much crowded on the anterior and posterior slopes of the shell, where, also, the greatest spinosity exists.

Cardium muricatum.

Figure 5.

Table E.

29	30	31	32	33	34	35	36	37	38	39
2	6	31	27	25	10	5	2			2

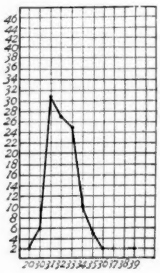


FIG. 5. *Cardium muricatum*. Curve of 110 specimens.

Number of shells examined 110. The range of variation is from 29 to 39, with a break between 36 and 39. The mode is at 31 with a frequency of 31, a strong minor mode at 32, with a frequency of 27 and a weaker minor mode at 33, with a frequency of 25. The width of this curve shows a considerable amount of variation. As in *isocardia*, the ribs are crowded at the anterior and posterior ends and the side ribs are frequently quite smooth.

Dall (*loc. cit.*, p. 1090) has examined 55 individuals of this species, gathered from all parts of its habitat, and the result is as follows:

Figure 6.

Table F.

30	31	32	33	34	35	36	37	38	39	40	41
2	9	5	8	7	8	6	5		3	1	1

A comparison of the two figures is interesting. The mode of curve No. 6 is at 31 with a frequency of 9 and two minor modes at 33 (frequency 8) and 35 (frequency 8). The breadth of this curve and its multimodal form shows a greater amount of variation in its entire range than do the specimens from near Tampa, in which the number of the ribs is more stable. The major mode, however, remains the same, showing that the normal number of ribs for this species is 31.

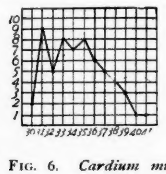


FIG. 6. *Cardium muricatum*. Curve of 55 specimens, selected from its entire range. (Dall.)

Dall makes the following remarks concerning the rib variation of *muricatum*. "The only generalization that seemed authorized is that the ribs are less numerous in specimens from near the northern border of the range of the species, and also in the fossils; the specimens with 37 to 41 ribs are nearly all from the southern half of the area inhabited. There was no diminution of ribs towards the southern extreme of the range and no regularity in the variations of the murication which could be correlated with difference of habitat."

Here again it would be interesting to know the results obtained by a quantitative study of a large amount of material from different localities.

V. Comparison of the Three Species.

Figure 7.

A comparison of the three species shows that *magnum* is the least variable, while *muricatum* is the most variable, as is shown by the width of the curve. *C. isocardia* seems to stand midway between these two species.

In the study of quantitative variation in the Mollusca the fact presents itself that in each species there is a mode or constant which remains unvaried and from which certain individuals vary sporadically. These would seem to be brought about by accidental variation rather than by natural selection.

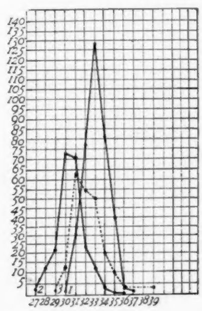


FIG. 7. Comparison of the three species. 1, *robustum*. 2, *isocardia*. 3, *muricatum*. (Classes doubled.)

In figure 7 it will be seen that each species has a particular and different constant. *C. magnum* (1) has 33 as a constant and shows a minimum of variation: *isocardia* (2) has 30 as a constant and *muricatum* (3) has 31 as a constant, but shows a large amount of variation.

It is evident from the above study that the number of ribs is not a safe character upon which to found a species. A small

number of specimens, 20 or 30, might show an apparent break in the numerical variation and seem to warrant the separation of some individuals as species, but a larger number of specimens shows that the number of ribs cannot be used in the separation of species without other more important characters.

It would be interesting to know the results obtained by an examination of a large number of specimens from different localities, to ascertain the stability of the data recorded in this paper.

My thanks are due to Professor C. B. Davenport of the University of Chicago for valuable suggestions in carrying on this study.

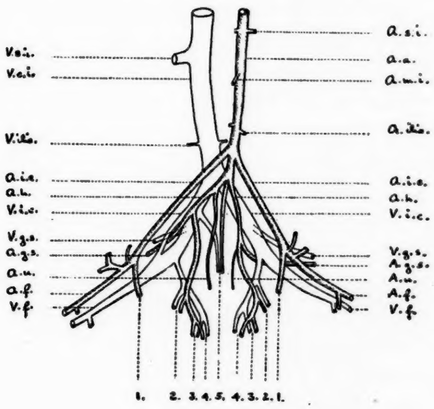
Chicago, Ill.

THE PERFORATION OF A VEIN BY AN ARTERY IN THE CAT (*FELIS DOMESTICA*).

ARTHUR W. WEYSSE.

In a cat which was being dissected in my laboratory a few months ago, I noticed an artery passing through an opening in a vein, and as further dissection showed the details of this abnormality to be somewhat different from any similar condition which I have found recorded it seemed well to publish the following figure and description.

The cat was an adult female; the circulatory system had been



injected with an ordinary starch injecting mass, the veins with blue and the arteries with red. For the sake of added clearness in the diagram the horns of the uterus were dissected free from the body-wall and together with the urinary bladder were laid back over the ventral side of the pubes; thus the umbilical arteries and the uterine arteries and veins are directed backward in the diagram instead of forward. It will be noticed that there is a longitudinal slit about a centimetre in length in the right

common iliac vein nearly opposite the point at which the superior gluteal branch of the internal iliac artery in given off, and through this slit the superior gluteal artery passes. This artery arises much farther cephalad than the left superior gluteal; the latter is in the normal position. The corresponding veins, on the other hand, arise symmetrically from the dorsal surface of the two common iliac veins. The opening does not divide the vein into tubes of equal diameter, that on the median side being much broader than the tube on the outside, but the lumen is uninterrupted on both sides of the slit.

Abnormalities in the vessels in this region are very frequent in the cat, and this same specimen shows one or two others. Thus while the right umbilical artery leaves the internal iliac at the usual point the left comes off much farther caudad than is customary and is much smaller than the right. The median sacral vein arises from the right common iliac instead of the left, an abnormality which has frequently been observed. In other respects, however, the vessels in this region of the cat in question take the normal course.

Not a few cases are on record of veins which have been perforated by arteries. McClure ('00) mentions two instances in the cat where lumbar arteries are found passing through a foramen in the inferior vena cava, and the same writer ('00) records four cases in the opossum where the spermatic arteries pass through foramina in the same vessel, the inferior vena cava; Hochstetter ('96) describes an Echidna embryo in which the inferior mesenteric artery passes through a foramen in the inferior vena cava. All of these abnormalities may be explained, however, if the inferior vena cava develops by a fusion of the posterior portions of the cardinal veins as appears probable; McClure ('00) mentions a number of cases in which the posterior cardinals persist in the adult cat, and if the fusion were to take place after the formation of the lumbar arteries, they would be left perforating the vein.

More nearly approaching the condition which I have found, are the four cases recorded for the cat by McClure ('00) in which the internal iliac artery passes through a foramen in the common iliac vein very near the point at which it divides into

the external and internal iliacs. This condition is not so readily explicable unless it should be shown that the internal iliac vein develops as a branch of the external, which again seems probable. If the internal iliac artery were first developed, the vein might well develop on both sides of it and thus become perforated.

A case which resembles mine still more closely is that figured by Treadwell ('96), — a perforation of the right common iliac vein by the right internal iliac artery; although this specimen was incomplete, the foramen appears to be much more cephalad than the point at which the internal iliac vein is given off, but here again it is the entire internal iliac artery which perforates the vein, instead of merely the superior gluteal branch as in my case.

Such abnormalities can only be explained by embryology, and very little appears to have been published on the development of the principal posterior branches of the dorsal aorta and the inferior vena cava. As to the way in which the perforation in question may have been brought about, the most reasonable explanation that has suggested itself to me is that the internal iliac artery grows out as a branch of the dorsal aorta before the common iliac vein develops from the inferior vena cava. If this should prove to be so, we can readily see that the anlage of the vein on coming in contact with the artery, or in this case its superior gluteal branch, might occasionally grow entirely around it instead of passing to one side. The fact that in the case figured the right superior gluteal artery arises from the internal iliac much farther forward than is usual and so comes to lie directly in the course of the right common iliac vein would seem to bear out this suggestion.

Blood vessels in the pelvic region of a cat, ventral aspect; the veins are in outline, the arteries shaded. The nomenclature adopted follows that used by Reigard and Jennings in their Anatomy of the Cat.

_A. a._ Aorta abdominalis.—_A. f._ A. femoralis.—_A. g. s._ A. glutea superior.—_A. h._ A. hypogastrica (iliaca interna).—_A. i. e._ A. iliaca externa.—_A. ilio._ A. iliolumbalis.—_A. m. i._ A. mesenterica inferior.—_A. s. i._ A. spermatica interna.—_A. u._ A. umbilicalis.—_V. c. i._ V. cava inferior.—_V. f._ V. femoralis.—_V. g. s._ V. glutea superior.—_V. i. c._ V. iliaca communis.—_V. ilio._ V. iliolumbalis.—_V. s. i._ V. spermatica interna.—1. _A._ profunda femoris.—2. _A._ and V. glutea inferior.—3 _A._ and V. hemorrhoidalis media.—4. _A._ and V. uterina.—5. _A._ and V. sacralis media.

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A PECULIAR MODIFICATION AMONGST PERMIAN DIPNOANS.

C. R. Eastman.

The genus Sagenodus is represented in this country by less than a dozen species, of which only three have been described from the Permian of Texas. These are *S. dialophus*, *S. periprion* and *S. porrectus*, all founded on detached dental plates of small size. The presence of a fourth species, different from any hitherto described, and displaying quite unusual modifications amongst ceratodonts, is indicated by several well preserved mandibular and palatine dental plates which have recently been brought to light by Dr. E. C. Case, of the State Normal School at Milwaukee, and kindly placed by him in the hands of the writer for description.

The present species occupies a unique position amongst fossil dipnoans in having a dentition adapted for cutting instead of crushing, thus paralleling the conditions found in certain Palæozoic sharks and in recent Gymnodonta. This divergence is the more striking in view of the singularly uniform type of dental system pervading lung-fishes throughout their entire geological history. Whether so extreme a variation is to be correlated with the change from marine to brackish-water conditions that took place during the Permian, with its very pronounced effects upon the environment and food-supply, may perhaps be plausibly conjectured.

In the new form, which may be named *Sagenodus pertenuis* in allusion to its chief peculiarity, the coronal grinding surface has become reduced to practically *nil* in the lower jaw, owing to compression of the inner margin into a sharp cutting edge, and disappearance of all except one of the outer radiating ridges. The upper dental plates differ from the lower in that two, instead of one, abbreviated coronal ridges are given off from the sharp angulation of the inner margin. The latter forms a continuous crest extending nearly to the symphysis anteriorly, and cor-

responds to both the foremost and hindmost of the coronal ridges in Ceratodus, plus the intermediate space. Hence it is proper to speak of an anterior and posterior, and one or two intermediate coronal crests as the case may be, according as we have to deal with mandibular or palatine dental plates. All of these coronal crests are serrated, the anterior one — which is at the same time the longest — coarsely, and the others finely, with sometimes as many as six or seven serrations each. The cutting edge in worn specimens furthermore displays a minutely crenulated appearance, owing to exposure of the dentine tubules, a condition very frequently observed in sharks' teeth. Both sides of the thin cutting edge exhibit a shining enameled surface, which passes gradually into a narrow base of vasodentine; and in the case of the mandibular dental plates at least, the pair was suturally united at the symphysis, much in the same fashion as in Ptyctodus and Rhynchodus (Fig. 1 *a*, *b*).

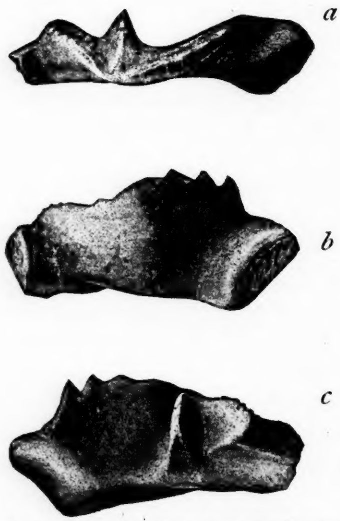

FIG. 1. *Sagenodus pertenuis sp. nov.* Permian; Texas. Left lower dental plate seen from the superior (*a*), inner (*b*) and outer (*c*) aspects $\times 2\frac{1}{2}$. The roughened sutural surface at the symphysis is shown in *C*.

The six specimens which the writer has examined are of comparatively small size, none exceeding a total length of 2 cm. and a height of 0.8 cm. In some examples the angulation of the inner margin is considerable, amounting almost to a right angle, and the short intermediate ridges have a tendency to become slightly curved backward. None of the dental plates exhibit marks of contact with those of the opposite jaw, but it is natural to suppose from the manner in which the lower pair were united, that essentially the same sort of contrivance was developed here as we have become familiar with in Peripristis from the upper Carboniferous, a modification which

is truly remarkable. When we recall also the aberrant series of Edestus-like sharks that flourished contemporaneously, we are struck with the fact that in two of the most conservative and persistent groups of fishes, namely the ceratodonts and cestracionts — both of which have had a continuous existence ever since the Devonian, — the extreme of variation was attained toward the close of the Palæozoic.

Another interesting feature to be brought forward in connection with the present form is its apparently wide distribution; and bearing in mind the world-wide scattering of the Edestus series that took place during the late Palæozoic, we note that the stimulus which quickened variation and distribution was responded to simultaneously by the two groups of fishes exceeding all others in longevity, after which they relapsed into sluggishness. The specimens obtained by Dr. Case, and one or two others belonging to the Münich Palæontological Museum, the latter having been acquired through Mr. Charles Sternberg, are all from the Cimarron series (upper Permian) of Wichita County, Texas. But it is further to be recorded upon the authority of Dr. Broili of Munich, who recently submitted the specimens under his charge for identification, that precisely the same form of tooth occurs in the Permian of Russia. Thus we have valuable additional evidence from the side of vertebrate palæontology regarding the homotaxial relationships of the Texas "Red Beds." The distinguishing features of the above described species may be briefly summarized as follows: — Dental plates relatively small, thin, the inner margin strongly angulated and sharpened into a continuous cutting edge, with a few coarse serrations in advance of, and finer ones behind the angulation. Mandibular dental plate with but one, and palatine dental plate with two short and narrow coronal ridges extending outwardly from the angulation of the inner margin, their crests finely serrated. Plates entirely without coronal grinding surface.

FIG. 2. *Sagenodus pertenuis sp. nov.* Oral aspect of left upper dental plate. × 2½.

CAMBRIDGE, MASS.

NOTES AND LITERATURE.

ZOÖLOGY.

Bailey's Birds of the Western United States.[1] — It is a great satisfaction to see a difficult task so well done as in Mrs. Bailey's *Birds of the Western United States.* Owing to the diversified nature of the area covered by the book, including the Plains, the Rocky Mts., the Great Basin, and the Pacific Slope, a very large number of species and subspecies had to be treated. There are careful descriptions of the different plumages of each species, an account of its distribution, and of its nest and food. These are followed by short but graphic biographies. In the case of many of the larger birds, the accounts of their habits have been supplied by Mr. Bailey, whose work in the West on the Biological Survey has enabled him to give great assistance. The introduction is evidence of the care with which the book has been planned. It contains directions for collecting birds, accounts of the life-zones and migration in the West, local lists and much other helpful matter. Attention is called to the vertical migration due to the height of the mountains. Certain hummingbirds, for instance, rear a second brood at a higher altitude than the first. There are abundant keys and illustrations. Thirty-three original full page illustrations and many cuts are by Fuertes. Most of these are well up to this artist's high standard. Occasionally as in the case of the Mearns' Quail, p. 122, and the Pileolated Warbler, p. 428, the effect is marred by the grotesqueness of some unusual attitude. A great many of the small cuts and diagrams with which the book abounds are really illustrative; it is a pity that so many pages are disfigured by the useless photographs from skins. The students of birds in the West are to be congratulated on now having a handbook which will prove as indispensable there as Chapman's is in the East.

R. H.

[1] Bailey, Florence Merriam. *Handbook of Birds of the Western United States.* Boston, Houghton, Mifflin & Co., 1902. 8vo. xc–512 pp., 33 pls., 601 text figs.

"The Water Fowl Family".[1] — The fourth volume in the *American Sportsman's Library* is an attractive book, which will doubtless prove of much value to those sportsmen who desire to extend their knowledge of the life habits of the game birds. It deals with the North American ducks, geese, swans, rails, and shore-birds. There are general descriptions of the families in each group, and accounts of each species, including their distribution, nesting and feeding habits. These have been compiled from standard authorities. There are also accounts from original observation of the behavior of each well-known species as it concerns the sportsman, and descriptions of the various methods employed in hunting it. An encouraging interest in bird protection is shown throughout the book; the "game hog" is condemned, and a close season in spring strongly advocated. It is a pity that a little of the cheap sporting-story element was included. The chapter on goose-shooting by the man who "hoped to preside at the obsequies of a goose" might well have been omitted. There are a number of excellent full page illustrations, three by Bull, and the rest by Fuertes.

R. H.

Ancestral Canidæ.[2] — Mr. J. B. Hatcher has published a paper of unusual interest on the Oligocene Canidæ lately discovered in Nebraska, and now preserved in the Carnegie Museum.[3] A full account is given of an almost complete skeleton of *Daphænus felinus*, Scott, and two new genera, Proamphicyon and Protemnocyon, are described. It is held that Daphænus has no known descendant; that Proamphicyon is ancestral to Amphicyon; and that Protemnocyon is ancestral to Temnocyon. This last animal is of particular interest, as it seems to be undoubtedly ancestral to Canis; that is, to the common dog. The discovery of Protemnocyon carries the known ancestry of the dog one stage further back; and, in fact, it was a very dog-like creature. The sagittal crest is quite as in the dogs; the two temporal crests of the foxes give their skulls a decidedly different appearance. The postorbital processes of the frontals are essentially as in the dogs, though short. The third

[1] Sanford, L. C., Bishop, L. B., and Van Dyke, T. S. *The Water Fowl Family.* New York, Macmillan, 1903. 8vo, ix–598 pp., 20 pls.

[2] See also an important article by Dr. W. D. Matthew (*Science*, June 5, 1903, p. 912) published since this notice was written.

[3] Oligocene Canidæ. *Mem. Carnegie Mus.* Vol. 1, pp. 65–108. Pls. XIV–XX.

molar is wanting, or perhaps occasionally present of very small size, in the upper jaw; present but very small in the lower. In the dog the third molar is usually absent in the upper, present in the lower jaw, but quite numerous cases have been found in which it was present in the upper jaw. Wortman and Matthew have held that the modern representative of Temnocyon is Cyon of India, which is little more than a subgenus of Canis; but as Mr. Hatcher remarks, this is problematical. Cyon is principally distinguished by the absence of the last lower molar, which would indicate that it is more specialized than Canis proper; the same character occurs as an aberration not rarely in the domestic dog and several wild species of Canis. It is to be remarked that the genus (Icticyon) which shows the greatest reduction of the molars (to one above and two below) is a native of South America. The top of the skull in Protemnocyon is flat in lateral view; in the coyote it is more elevated, while in the domestic dog it is strongly convex; these changes no doubt accompanying a progressive development of the brain, though partly the result also of enlarged frontal air-sinuses. In Temnocyon the absence of the third molar in the lower jaw suggests Cyon rather than Canis proper, but it does not seem impossible that this molar might be lost and recovered again (contrary to the doctrine of some), considering the comparative frequency of an extra (fourth) molar in the lower jaw of the common dog. However, while Temnocyon stands nearer to Canis than does Protemnocyon, both in time and by the auditory bullæ, it may still be a little out of the direct line.

T. D. A. C.

Parker on the Hearing of Fishes.[1]— Professor G. H. Parker gives an account of his studies of the sense of hearing in fishes. Taking the common Killifish, *Fundulus heteroclitus* as the subject of experiment, he shows that this fish does actually hear sounds which may be made by means of tuning forks, and that it becomes deaf on cutting the auditory nerve. It is possible that fishes of other species may be actually insensible to sounds as experiments of others have seemed to show, and in all fishes the ear may be in part an organ of equilibration.

It is of course not likely that any fish has the power to make fine discriminations in sounds.

[1] Parker, G. H. Hearing and Allied Senses in Fishes. *Bull. U. S. Fish Com. for 1902*, pp. 45–64, pl. 9.

The lateral line is closely associated with the air, and may also assist at hearing. The ear is an outgrowth from the tubes of the lateral line. As Professor Parker aptly observes, in the skin, the lateral line and the ear, "we are dealing with what may be called three generations of sense organs: the skin representing the first generation and giving rise to the lateral line organs, the second, which in turn produce the ears."

D. S. J.

Parker on the Optic Nerves of Flounders.[1]— In the bony fishes, the optic nerves pass to the optic lobes of the brain, the one passing to the lobes of the opposite side simply lying over the other, without intermingling of fibres, such as takes place in the higher vertebrates and in the more primitive fishes.

According to Parker's observations, in ordinary bony fishes, the right nerve may be indifferently above or below the other. In 1000 specimens of ten common species, 486 have the left nerve uppermost and 514 the right nerve. In most individual species, the numbers are practically equal. Thus, in the haddock, 48 have the left nerve uppermost and 52 the right nerve.

In the unsymmetrical Teleosts or flounders, and soles, this condition no longer obtains. In those species of flounder with the eyes on the right side, 236 individuals representing sixteen species had the left nerve uppermost in all cases.

Of flounders with the eyes on the left side, 131 individuals representing nine species all have the right nerve uppermost.

There are a few species of flounders in which reversed examples are so common that the species may be described as having the eyes on the right or left side indifferently. In all these species, however, whether dextral or sinistral, the relation of the nerves conforms to the type, and is not influenced by the individual deviation. Thus the stony flounder (Platichthys) belongs to the dextral group. Fifty normal specimens, the eyes on the right, have the left nerve dorsal, while the left nerve is also uppermost in 50 reversed examples with eyes on the left. In 15 examples of the California bastard halibut (*Paralichthys californicus*) normally sinistral, the right eye is always uppermost. It is uppermost in 11 reversed examples.

[1] Parker, G. H. The Optic Chiasma in Teleosts and its Bearing on the Asymmetry of the Heterosomata (Flat Fishes) *Bull. Mus. Comp. Zoöl.*, Vol. XL, No. 5, pp. 221–242, 1 pl.

Among the soles this uniformity or monomorphism no longer obtains. In forty-nine individuals of four species of dextral soles, the left nerve is uppermost in 24, the right nerve in 25. Among sinistral soles, or tongue fishes, in 18 individuals of two species, the left nerve is uppermost in 13, the right nerve in 5.

Professor Parker concludes from this evidence that soles are not degenerate flounders, but rather descended from primitive flounders which still retain the demorphic condition as to the position of the optic nerves, a condition still retained by all bony fishes except the flounders.

The lack of symmetry among the flounders lies therefore deeper than the matter of the migration of the eye. The asymmetry of the mouth is an independent trait, but like the migration of the eye, is an adaptation to swimming on the side. Each of the various traits of asymmetry may appear independently of the others.

The development of the monomorphic arrangement in flounders, Professor Parker thinks, can be accounted for by the principle of natural selection. In a side-swimming fish, the fixity of this trait has a mechanical advantage. The unmetamorphosed young of the flounder are not strictly symmetrical, for they possess the monomorphic position of the optic nerve. The reversed examples of various species of flounders (these, by the way, chiefly confined to the California fauna) afford "striking examples of discontinuous variation."

Professor Parker inclines to the opinion that the ancestral flounders were allied to the john dories. This is as plausible a guess as any. They certainly have no affinity with the cod-fishes.

D. S. J.

Notes on Recent Fish Literature.— Mr. C. T. Regan (*Proc. Zoöl. Soc. London*) takes up the osteology of the plectognathous fishes and the classification derived from it. The chief character of the group as distinguishing it from their ancestors, the Acanthuridæ is the absence of ribs. He divides the plectognaths into two divisions, the Sclerodermi and the gymnodontes. To the former group the Ostracodermi are referred. The supposed families of Chonerhinidæ and Tropedechebyidæ are regarded as not distinct from Tetraodontidæ and doubt is thrown on the accuracy of the figures of Hollard which have served as the basis for certain generic distinctions.

The Mexican trigger-fish *Balistes naufragium* is said to be a species of Xanthichthys, a genus rejected by Mr. Regan.

In the *Annals and Magazine of Natural History* (XII, 459–466) Mr. Regan discusses the osteology and classification of the anacanthine or cod-like fishes. He regards the absence of foramen in the hypercoracoid, which separates the cod-fishes from the true jugular fishes (blennies, etc.) as a matter of minor importance, because the same trait is found in several trachinoid fishes, which are true jugular fishes. In the cod-like fishes or Anacanthini, the ventral fins, sometimes many-rayed, are below or in front of the ventrals, "while the pelvic bones are posterior to the clavicular arch to which they are loosely attached by a ligamentous connection." In the true Jugulares the ventrals, with 6 rays or fewer, are jugular, "the pelvic bones being distinctly and firmly attached to the clavicular symphysis." The true Jugulares are, of course, modified Acanthopteri. In Mr. Regan's opinion "the Gadoids originated from some less specialized stock," their peculiar features being largely primitive. He suggests their possible derivation "from some Haplomous stock from which the Berycidæ have also descended, and of which the Stephanoberycidæ are the nearest living representatives."

In Mr. Regan's view the Macrouridæ are more primitive than the cod-fishes. In this family, Melanomus and Lyconus should be placed. Bregmaceros, wrongly placed near the Brotulidæ, has the general structure of the cod-fishes. Muraenolepis is the type of a distinct family. Mr. Regan describes a new genus, Gadomus, based on *Bathygodus longifilis*. In this genus there is a slit behind the last gill, and the hypercoracoid unlike that of all other Anacanthini is perforate. Melanobranchus, another new genus, has the slit behind the last gill, but the hypercoracoid is as in other Macrouri.

In a recent paper (*Ann. Mag. Nat. Hist.*, XI, 372–374) Mr. Regan discusses again the skeleton of *Lervanes imperialis*, deciding finally that it is a highly aberrant scombroid fish.

Dr. Peter J. Schmidt in *Proceedings of the Museum of St. Petersburg* discusses in Russian, and later in German the fauna of the Seas of Japan and Okhotsk. In both these seas the species of fishes are distinctly sub-arctic; although some shore-fishes enter from the ordinary Japanese fauna, these waters are very rich in agonoid and Cottoid fishes, far more so than the corresponding latitudes in the Atlantic. A number of new species are indicated by name, soon to be described.

In the series of monographic reviews of the fishes of Japan, Messrs

Jordan and Fowler (*Proc. U. S. Nat. Mus.*, XXV, 939–956) treat of the fishes known as dragonets, constituting the family of *Callionymidæ.* Of these fishes 12 species are described, and the new species and some of the others are well figured by Captain C. B. Hudson. One species, *Draconetta xenica* constitutes a new family and a new genus, Calliurichthys is proposed for the dragonets with spear-like preopercular spine.

D. S. J.

Häcker's Autonomy of the Germ Nuclei.[1] — This work is in the main an extension of Häckers earlier papers, (1892, 1896) on the autonomy of the male and female pronuclei and of their derivatives in the development of limnetic Copepods. To this central theme he has added two introductory chapters on the ecological (biologische) relations and on the general developmental phenomena of copepods, a chapter on the maturation phenomena of Cyclops and another in which he seeks to extend the idea of the autonomy of the germ nuclei to many classes of plants and animals. These nuclear halves he designates "Gonomeres" while the vesicles formed from individual chromosomes (chromosomal vesicles) he calls "Idiomeres." These names are definite, convenient and really necessary to avoid descriptive phrases and it is desirable that they should come into general use.

The author thinks it is possible to follow this autonomy of the gonomeres from the first to the third generation, but his stages are by no means complete; in fact they consist only of a few cleavage and gastrulation stages and of the developing gonad. His methods of distinguishing the cells of the germ track ("*Keimbahnzellen*") are the following: (1) The autonomy of gonomeres is here preserved longest. (2) Nuclear divisions are here heterotypic, (3) The rhythm of division is here slower than elsewhere, (4) Ectosomes (dark staining granules) are eliminated from the nuclei of the germ track cells, thus suggesting the chromatic diminution of Ascaris. The autonomy of the gonomeres is determined chiefly by the presence of two nucleoli within a nucleus, though in cases where there is a long resting period this number may be reduced to one. Evidently the significance of this is that there are as many nucleoli as there are idiomeres or chromosomal vesicles and when during a long rest-

[1] Häcker, Valentin. *Ueber das Schicksal der elterlichen und grosselterlichen Kernanteile, Morphologische Beiträge zum Ausbau der Vererbungslehre.* Jena. Fischer, 1902. 8vo, pp. 104, 4 plates, 16 text figures.

ing period the two gonomeres fuse a fusion of their nucleoli also occurs.

With regard to the fate of the maternal and paternal halves during maturation the author says that there are three possibilities: Either (1) a complete separation of the halves (Mendel's principle), (2) a symmetrical mixing of nuclear constituents, or (3) an unsymmetrical mixing. He concludes that the first maturation is an equation division and that the reduction occurs in the second maturation in such a manner "that the ripe egg cell contains one half of the grand paternal and one half of the grand maternal chromosomes" thus fulfilling the second possibility named above.

The conclusion which the author reaches that the reduction is brought about by a fusion of maternal and paternal chromosomes at the time of the 2d maturation division is not sufficiently well supported, especially in view of the fact that recent work, particularly that of Montgomery and of Sutton, has shown that this fusion occurs at a period long preceding the first maturation.

BOTANY.

Notes. — The *Botanical Gazette* for January contains the following articles: — J. D. Smith, "Undescribed Plants from Guatemala and Other Central American Republics, XXIV"; Arthur, "Cultures of Uredineæ in 1902"; Dean, "Experimental Studies on Inulase"; Livingston, "The Distribution of the Upland Plant Societies of Kent County, Michigan"; and Schneider, "Contributions to the Biology of Rhizobia."

The *Bulletin of the Torrey Botanical Club* for January contains the following articles: — Arthur, "Problems in the Study of Plant Rusts"; Evans, "Hepaticæ of Puerto Rico — II. *Drepano-lejeunea*"; Underwood, "An Index to the Described Species of Botrychium"; and Kellerman, "The Effects of Various Chemical Agents upon the Starch-converting Power of Taka Diastase.

Floral Life is the title of a new journal which begins in January, its first number being also noted as "Old Series No. 139," it being a continuation of *Meehan's Monthly*.

The *Plant World* for December, with a portrait of F. H. Knowlton as frontispiece, contains the following articles: — Niles, "Origin of Plant Names — IV; Parish, San Jacinto Mountain"; Wallace, "The Preservation of our Wild Flowers, Shrubs and Trees"; Williams, "Where Lichens grow"; Knowlton, "Fossil Mosses"; and Pollard, "Cocoanuts in Cuba." As a supplement to this number, — the title page, etc., of Mr. Pollard's *The Families of Flowering Plants.*

Rhodora for January contains the following articles: — Collins, "North American Ulvaceæ"; Bissell, "A Botanical Trip to Salisbury, Ct."; Knowlton, "Flora of Mt. Saddleback, Me."; Leavitt, "Outgrowths on the Leaf of Aristolochia"; Pease, "*Erodium malacoides* at Lawrence, Mass."; Bissell, "*Lycopodium clavatum* and its variety"; and Graves, "*Schwalbea Americana* in Ct."

An article on "The Functional Inertia of Plant Protoplasm," by Robertson, is published in Vol. III, No. 3, of the *Proceedings of the Scottish Microscopical Society.*

"Plant Physiology for the High School," by Ganong, and "High School botany," by Syndam, are articles in *School Science* for February.

A fossil flora of the John Day Basin, Oregon, constitutes *Bulletin No. 204* of the U. S. Geological Survey.

From the structure of their seedlings, Miss Sargant argues, in the *Annals of Botany* for January, that the monocotyledons are derivatives of dicotyledons, rather than the reverse.

The anatomy of *Macrozamia heteromera* is written on by Agnes Robertson in Vol. XII, part 1 of the *Proceedings of the Cambridge Philosophical Society.*

In No. 8 and 9 of *the Pharmaceutical Archives* for 1902, Perrédès and Power respectively discuss the anatomy and the chemistry of *Derris uliginosa,*— an Eastern fish poison; No. 1 of *The Pharmaceutical Archives* for 1903, also, containing the conclusion of Dr. Power's paper.

Chrysanthemum indicum, one of the original sources of the many cultivated "Chrysanthemums," is figured, accompanied by a note by Sir Joseph Hooker, in *Curtis's Botanical Magazine* for January.

"Growing Cuban tobacco in the United States" forms the subject of an illustrated article by Marrion Wilcox, in *The World's Work* for February.

Part 4 of Arthur and Holway's "Descriptions of American Uredineæ" is published, with line illustrations, in Vol. V, no. 3 of the *Bulletin* from the Laboratories of Natural History of the State University of Iowa, dated in October. It may not be known generally that the exsiccatæ of the same authors are further illustrated by excellent photographic representations of the species distributed.

Torreya for January contains: Gleason, "Notes on Some Southern Illinois Plants"; Watterson, "Louise Brisbin Dunn"; Lloyd, "Vacation Observations — III"; Grout, "Leaves of the Skunk Cabbage"; Murrill, "A New Family of the Basidiomycetes" (Xylophagaceæ, based on Xylophagus and allied genera); Cockerell, "A New Oak — *Quercus rydbergiana*"; and Berry, "Insect Visitors of *Scrophularia leporella*."

The 1902 *Bericht der Senckenbergischen Naturforschenden Gesellschaft* contains lectures by Möbius on carnivorous plants, Askenasy on the phenomena of swelling, and Kinkelin on the development of the plant world with reference to recent fossil collections.

An article on Droseras, in which several species are figured, is published in *Die Gartenwelt* of January 10th.

Additional observations on The Strand Flora of New Jersey, by Harshberger, have been separately issued from the *Proceedings of the Academy of Natural Sciences of Philadelphia*, for October, under date of December 12th.

Part 16 of J. M. Macoun's "Contributions to Canadian Botany" is published in *The Ottawa Naturalist* for February.

A flora of the town of Southington, Conn., and its vicinity, by Bissell and Andrews, has been published as Connecticut School Document No. 15, issued by the State Board of Education in 1902.

A short article on Santo Domingo, by Harshberger, has been reprinted from *Education* of January.

Ginseng culture is the subject of *Bulletin No. 62* of the Pennsylvania Agricultural Experiment Station.

"How to grow a Forest from Seed" is the title of *Bulletin No. 95* of the New Hampshire Agricultural Experiment Station.

A well illustrated article on "The Mango in Porto Rico," by G. N. Collins, is published as *Bulletin No. 28* of the Bureau of Plant Industry of the Department of Agriculture.

Arboriculture for January is largely devoted to the hardy Catalpa, *C. speciosa.*

Country life in America, for February, contains among other interesting things an article on the orange in Florida, by Webber, and one on orange growing in California, by Holder.

A well illustrated popular article on the date palm, by Sajo, is contained in *Prometheus* for January.

A list of American varieties of vegetables for the years 1901 and 1902, by W. W. Tracy, Jr., is published as *Bulletin No. 21* of the Bureau of Plant Industry of the Department of Agriculture, and forms a closely printed pamphlet of 402 pages.

No. 1 of Vol. VIII of the *Anales del Museo Nacional de Buenos Aires* contains Nos. 51 to 190 of Spegazzini's "Mycetes Argentinenses," the signatures of which are dated July 16, 1902.

The Gardener's Chronicle of January 24 contains a portrait and short obituary of Wendland.

The *Botanical Gazette* for March contains the following articles: Thaxter, "New or peculiar North American Hyphomycetes, III"; Copeland, "Chemical Stimulation and the Evolution of Carbon Dioxid (concluded)"; Coulter and Chamberlain, "The Embryology of Zamia"; Fink, "Some Talus Cladonia Formations"; Reed, "Development of the Macrosporangium of *Yucca filamentosa*"; Greenman, "Faxonanthus"; and Hitchcock, "Notes on North American grasses."

The Bulletin of the Torrey Botanical Club for March contains the following articles: Cannon, "Studies in plant hybrids — The spermatogenesis of hybrid cotton"; Britton, "Timothy Field Allen" (with portrait); Vail, "Studies in the Asclepiadaceæ, VII. A new species of Vincetoxicum from Alabama"; and Piper, "A new species of Waldsteinia from Idaho."

The American Botanist for March contains the following popular articles: C. F. Saunders, "Early spring in southern California"; Turnbull, "Concerning nomenclature"; and Gœtting, "A rare perfume."

The first *Yearbook of the Carnegie Institution of Washington*, recently issued, contains much interesting information concerning the botanical work being planned, later details of which are noted in recent issues of *Science.*

The "Osservazioni scientifiche eseguite durante la spedizione polare di S. A. R. Luigi Amadeo di Savoia," Milan, 1903, contains among other things, chapters on phanerogams by Belli and cryptogams by Mattirolo.

The Flora of Tropical Africa, edited by Sir W. T. Thiselton-Dyer, has reached No. 3 of Vol. IV, comprising Asclepiadeæ, in part, to Gentianeæ, in part.

A developmental account of African Park-lands, by Professor Tansley, with illustrations, appears in *The New Phytologist* of February 16.

Contributions to Western Botany, No. 11, of Marcus E. Jones issued April 10, 1903, is largely occupied with Abronia, Oxytheca, Eriogonum and Atriplex.

An account of the pine-woods of Florida, by Leplæ, appears in recent numbers of the *Bulletin de la Société Centrale Forestière de Belgique.*

The question as to what constitutes an "annual" is discussed by Praeger in the *Irish Naturalist* for April.

A new Lower-Californian palm, *Erythea brandegeei*, is described and figured by Purpus in *Gartenflora*, Vol. LII.

A number of new Mexican grasses are described by Hackel in the opening number of Vol. XVII of the *Annalen des K. K. Naturhistorischen Hofmuseums* of Vienna.

The Ottawa Naturalist for April contains a paper by Evans on Yukon Hepaticæ.

The Bryologist for March contains the following articles: Fink and Husband, "Notes on Certain Cladonias"; Barbour, "Hepatics Lejeunea"; Holzinger, "Karl Gustave Limpricht (part 2)"; Holzinger, "Some notes on collecting"; Grout, "*Pogonatum brevicaule*"; Williams, "*Psilopilum tschuctschicum;*" and Nicholson, "*Mnium insigne.*"

Separates of Dr. Galloway's vice-presidential address at the Pittsburg meeting of the American Association for the advancement of Science, on applied botany, retrospective and prospective, have been distributed recently.

An economic study of Sequoia, published as *Bulletin No. 38* of the Bureau of Forestry of the United States Department of Agriculture, contains the following chapters:— Fisher, "A study of the redwood";

von Schrenk, "The brown rot Disease of the Redwood"; and Hopkins, "Insect Enemies of the Redwood."

Data on the self-fertility of the grape, comprising studies of the potency of the pollen of self-sterile grapes, the influence on self-fertility of girdling or bending the canes, and the pollen of the grape, are published by Beach and Booth in *Bulletins No. 223-4* of the New York Agricultural Experiment Station.

An exhaustive study of the injury of plants by smoke and gases, by Haselhoff and Lindau, has been issued from the press of Borntræger Brothers, of Leipzig.

An account of *Polyporus fraxinophilus* and its effects on the white ash, by von Schrenk, constitutes *Bulletin No. 32* of the Bureau of Plant Industry of the Department of Agriculture.

Professor Arthur's Washington address as President of the Botanical Society of America, on problems in the study of plant rusts, has been distributed by the secretary of the society.

The relation between frost-injury and parasitic infection in cereals is discussed by Sorauer in *Landwirtschaftliche Jahrbücher*, Vol. XXXII, Heft 1, issued in March.

Among the complicated series and sub-series of University Bulletins that have appeared in recent years as a means of securing periodical mailing privileges, is to be noted an *Ohio Mycological Bulletin*, forming part of the botanical series of the bulletins of the university of that state.

The *Journal of Mycology* for February, with portrait of Dr. Farlow as frontispiece, contains the following articles: Bubak, "Zwei neue Pilze aus Ohio"; Morgan, "*Lepidoderma geaster*"; Kellerman, "A new species of Cephalosporium"; Kellerman, "Uredineous infection experiments in 1902"; Stevens, "Notes on *Sclerospora graminicola*"; Atkinson, "A new species of Calostoma"; Kellerman, "Ohio Fungi, fascicle VI, [labels and notes]"; Kellerman, "Index to North American Mycology"; and Kellerman, "Notes from mycological literature, IV."

The petiolar nectar glands of Viburnum, which form the subject of a paper by Thouvenin in No. 171 of the *Revue Générale de Botanique*, are homologized with leaflets of a compound leaf.

An interesting account of variations in the occurrence of salicin

and salinigrin in different willow and poplar barks, by Jowett and Potter, is issued as No. 28 of the publications of *The Wellcome Chemical Research Laboratories.*

The *Berichte der Deutschen Botanischen Gesellschaft* of March 25, 1903, includes a paper by Rosenberg on the chromosomes of a Drosera hybrid, and a paper by Correns on the dominating characteristics of hybrids.

From a statement by the Director in *Bulletin du Jardin Impériale Botanique de St. Pétersbourg*, Vol. III, Livraison 1, it appears that 35,358 persons visited the extensive plant-houses of that great establishment in 1902, the yearly average for the past thirty years being 20,655.

The concluding number of Vol. II of the *Bulletin of the New York Botanical Garden*, issued in March, shows the incorporation of about 90,000 herbarium specimens, the addition of 1962 bound volumes to the library, and the increase of species of plants cultivated in the Garden to about 10,600, for 1902.

An account of the Glasgow Botanical Garden is contained in *The Gardeners' Chronicle* of February 28.

In the recently commenced *Bulletin du Jardin Botanique de l'Etat à Bruxelles*, Professor Massart discusses the problem of gardens for the class purposes of secondary schools, and gives a list of 72 desirable species, including one Fungus, one Alga, four Bryophytes, and three Pteridophytes, with instructions for the more difficult phases of the gardening.

Country Life in America for March is a gardening issue, adequately illustrated.

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(Regular exchanges are not included.)

COHEN, C. Physical Chemistry for Physicians and Biologists. Translated from the German by M. H. Fischer. New York, Henry Holt & Co., 1903. 8vo, viii+343 pp., 49 figs. — DRIESCH H. Die Seele als elementarer Naturfaktor. Studien über die Bewegungen der Organismen. Leipzig, Engelmann, 1903. 8vo, vi + 97 pp. Marks 1.60. — GARDINER, J. S. The Fauna and Geography of the Maldive and Laccadive Archipelagoes. Vol. i, pt. iv, pp. 347–471, Pls. XVIII–XXV, text-figs. 76–119. Cambridge, University Press, 1903. 15/. — HUNTER, S. J. Elementary Studies in Insect Life. Topeka, Crane & Co. 8vo, xviii + 344 pp., 234 figs. — NISSL, F. Die Neuronenlehre und ihre Anhänger. Jena, Fischer, 1903. 8vo, 478 pp., 2 pls. Mk. 12. — RADL, E. Untersuchungen über den Phototropismus der Tiere. Leipzig, Engelmann, 1903 8vo, viii + 188 pp. Mk. 4. — REDFIELD, C. L. Control of Heredity. A Study of the Genesis of Evolution by Diagrams and Types of Character. Chicago and Philadelphia, Monarch Book Co., 1903. 8vo, 343 pp. Illustrated. — SHERBORN, C. D. Index Animalium sive Index Nominum quae ab A. D. MDCCLVIII Generibus et Speciebus Animalium imposita sunt. Sectio Prima a kalendis Januariis MDCCLVIII usque ad finem Decembris, MDCCC. Cambridge, University Press, 1902. 8vo, lix + 1195 pp. 25/. — SNODGRASS, R. E. The Anatomy of the Carolina Locust. (Dissosteira Carolina Linn.). A Manual for Teachers and Students. Pullman, Washington, Wash. Agr. Coll. 1903. 8vo., 50 pp., 6 pls. $0.50. — VERRILL, A. E. The Bermuda Islands. An account of their Scenery, Climate, Productions, Physiography, Natural History and Geology, with Sketches of their Discovery and Early History, and the changes in their Fauna and Flora due to Man. New Haven, published by the author, 1902. 8vo, x + 548 pp., 38 pls. and 250 text-figs. — VERNON, H. M. Variation in Animals and Plants. New York, Henry Holt & Co., 1903. 8vo, ix + 415 pp., 30 figs. — VON ZITTEL, K. A. Text Book of Palæontology. Translated and Edited by C. R. Eastman. Vol. II. London, Macmillan, 1902. 8vo, viii + 283 pp., 313 figs., $2.75.

BERRY, E. W. Notes on Sassafras. *Bot. Gazette.* Vol. xxxiv, pp. 426–450, pl. 18 and 4 figs. — COCKERELL, T. D. A. A New Cocklebur from New Mexico. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 9–10. — CONDRA, G. E. New Bryozoa from the Coal Measures of Nebraska. *Amer. Geologist.* Vol. xxx, pp. 337–359, pls. 18–25. — CUMMINGS, E. R. The Morphogenesis of Platystrophia. A Study of the Evolution of a Paleozoic Brachiopod. *Am. Jour. Sci.* Vol. xv, 63 pp., 27 figs. — DALL, W. H. Review of the Classification of the Cyrenacea. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 5–8. — DAVENPORT, C. B. The Animal Ecology of the Cold Springs Sand Spit. *Univ. Chicago Decen. Publ.* Vol. x, pp. 157–176. 7 figs. — DAVIS, B. M. Oogenesis in Saprolegnia. *Univ. of Chicago Decennial Publications.* Vol. x, pp. 227–33, pls. 15–16. — DAVIS, K. C. Peach Growing in West Virginia. *Bull. W. Va. Agr. Exp. Sta.* No. 82, pp. 339–441. 16 figs. — DEAN, BASHFORD. Japanese Oyster Culture. *Bull. U. S.*

Fish Com. for 1902. Pp. 17–37, pls. 3–7. — DUERDEN, J. E. On the Actinian Bunodeopsis globulifera Verrill. *Trans. Linn. Soc. London.* Vol. viii. Pt. 9, pp. 296–317. Pls. 25–26. — DUERDEN, J. E. The Morphology of the Madreporaria. III. The Significance of Budding and Fission. *Ann. Mag. Nat. Hist.* Ser. 7, vol. x, pp. 382–393. 4 figs. — DUERDEN, J. E. The Morphology of the Madreporia. IV. Fissiparous Gemmation. *Ann. Mag. Nat. Hist.* Ser. 7, vol. xi, pp. 141–155. 7 figs.— DUERDEN, J. E. West Indian Madreporarian Polyps. *Mem. Natl. Acad. Sci.* Vol. viii, pp. 399 + 645, 25 pls. and 39 figs.— DURY, C. A Revised List of the Coleoptera observed near Cincinnati, Ohio, with Notes on Localities, Bibliographical References and Description of Six New Species. *Journ. Cincin. Soc. Nat. Hist.* Vol. xx, pp. 107–196. 5 figs. — FISH, P. A. The Cerebral Fissures of the Atlantic Walrus. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 675–688, pls. 28–29.— GILL, THEO. The Use of the Name Torpedo for the Electric Catfish. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 697–698.— HATCHER, J. B. A New Sauropod Dinosaur from the Jurassic of Colorado. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 1–2.— HAY, O. P. On Certain Genera and Species of North American Cretaceous Actinopterous Fishes. *Bull. Amer. Mus. Nat. Hist.* Vol. xix, pp. 1–95, pls. 1–v and 72 figs.— HELLER, E. Papers from the Hopkins Stanford Galapagos Expedition, 1898–1899. XIV. Reptiles. *Proc. Wash. Acad. Sci.* Vol. v, pp. 39–98.— HOWELL, A. H. Three New Skunks of the Genus Spilogale. *Proc. Biol. Soc. Wash.* Vol. xv, pp. 241–242.— JORDAN, D. S. Supplementary Note on Bleekeria mitsukurii and of Certain Japanese Fishes. *Proc. U. S. Natl. Mus.* Vol. xxvi, 693–696, 4 figs.— JORDAN, D. S., and EVERMANN, B. W. Descriptions of New Genera and Species of Fishes from the Hawaiian Islands. *Bull. U. S. Fish Comm. for 1902.* pp. 161–208.— JORDAN, D. S. and FOWLER, H. W. A Review of the Cepolidæ or Band-Fishes of Japan. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 699–702, 1 fig.— JORDAN, D. S. and FOWLER, H. W. A Review of the Cobitidæ or Loaches of the Rivers of Japan. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 765–774, 2 figs.— JORDAN, D. S. and STARKS, C. E. Description of a New Species of Sculpin from Japan. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 689–690, 1 fig.— KELLOGG, V. L. The Net-Winged Midges (Blepharoceridæ) of North America. *Proc. Cal. Acad. Sci. Zöol.* Vol. iii, pp. 187–232, pls. 18–22.— KRAEMER, H. The Pith Cells of Phytolacca decandra *Torreya.* Vol. ii, pp. 141–143.— LYDELL, D. The Habits and Culture of the Black Bass. *Bull. U. S. Fish. Com. for 1902.* pp. 39–44, pl. 8.— MAIDEN, J. H. On the Identification of a Species of Eucalyptus from the Philippines. *Proc. U. S. Natl. Mus.* Vol., xxvi, pp. 691–692.— MAYER, A. Z. The Atlantic Palolo. *Sci. Bull. Mus. Brooklyn Inst.* Vol. i, No. 3, pp. 93–103.— MENNELL, F. P. The Zimbawe Ruins. *Rhodesia Mus. Special Rept.* 16 pp., 6 pls.— MERRIAM, C. H. Two New Wood Rats (Genus Neotoma) from State of Coahuila, Mexico. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 47–48.—MILLER, G. S., Jr. A New Bat from the Island of Dominica. *Proc. Biol. Soc. Wash.* Vol. xv, pp. 243–244.— MILLER, G. S., Jr. Two New Tropical Old World Bats. *Proc. Biol. Soc. Wash.* Vol. xv, pp. 245–240.— MILLER, G. S., Jr. Descriptions of Eleven New Malayan Mouse Deer. *Proc. Biol. Soc. Wash.* Vol. xvi, pp. 31–44.— MILLER, G. S., Jr. Mammals collected by Dr. W. L. Abbott on the Coast and Islands of Northwest Sumatra. *Proc. U. S. Natl. Mus.* Vol. xxvi, pp. 437–484, pls. 18–19.— MILLSPAUGH, C. F. Plantæ Yucatanæ (Regionis Antillanæ). Plants of the Insular, Coastal and Plain Regions of the Peninsula of Yucatan, Mexico. Fasc. I.

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Animal Life and the World of Nature. No. 5.— *Bulletin of the Geological Institution of the University of Upsala.* Vol. v, pt. 2, No. 10.— *Bulletin Johns Hopkins Hospital.* Vol. xiv, Nos. 143-145, Feb.-Apr.— *Bulletin New York Zoölogical Society.* No. 8, Jan.— *Condor, The.* Vol. v, Nos. 1 and 2. Mch.-Apr. *Entomological Society of Ontario, 33d Ann. Rept.* 132 pp., 106 figs.— *Field Columbian Museum, Annual Report of the Director* for the year 1901-1902.— *Forestry Quarterly.* Vol. i, No. 2.— *Illinois State Laboratory Natural History Biennial Report of the Director* for 1899-00, 12 pp.— *Journal of Mycology.* Vol. viii, No. 63. *Marine Biological Laboratory, Ninth Report* for the years 1896-1899, 198 pp.— *Naturwissenschafliche Wochenschrift.* Bd. xviii, Nos. 14-17.— *New Century, The.* Vol. vi, Nos. 7-20.— *Nuova Notarisia, La.* Ser. xiv. Oct. and Jan.— *Papoose, The.* Mch.— *Proceedings of the Natural Science Association of Staten Island.* Vol. viii, No. 19.— *Revista Chilena de Historia Natural.* Año vi, No. 3. —*Rhodesia Museum, Bulawayo, First Annual Report.* 1902, 14 pp.—*School Science.* Vol. ii, No. 8, Vol. iii, No. 1. Apr.— *Tuavaux & Memoires de L'Université de Lille.* Tom. x, Mem. 29.— *U. S. Department of the Interior, Report of the Commissioner of Education* for the year 1900-1901. Vol. ii, pp. 1217-2512.

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